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ELEMENTS

OF

SURVEYING

AND

LEVELLING;

WITH

DESCRIPTIONS OF THE INSTRUMENTS AND THE
NECESSARY TABLES.

By CHARLES DAVIES, LL. D.,

AUTHOR OF A FULL COURSE OF MATHEMATICS.

A. S. BARNES & COMPANY,
NEW YORK AND CHICAGO.
1874.

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S.

PREFACE.

The Elements of Surveying, first published in 1830, was designed as a text-book for the pupils of the Military Academy, and in its preparation little regard was had to the supposed wants of other institutions.

The work, however, was received by the public with more favor than was anticipated, and soon became a leading text-book in the Colleges, the Academies, and the higher grade of Schools.

For the purpose of adapting it more fully to the supposed wants of these institutions, many changes have been made since its first publication; and the present edition will be found to differ, in many respects, from those which have preceded.

It has been the intention to begin with the very elements of the subject, and to combine those elements in the simplest manner, so as to render the higher branches of Plane Surveying comparatively easy. All the instruments needed for plotting have been carefully described; and the uses of those required for the measurement of angles are fully explained.

The conventional signs adopted by the Topographical Bureau, which are now used by the United States Engineers in all their Charts and Maps, are given in plates 5 and 6.

Should these signs be generally adopted in the country, it would give entire uniformity to all maps and delineations of ground, and would establish a common language by which all the peculiarities of soil and surface could be accurately represented.

A full account is also given of the system adopted in the survey of the public lands; and, although the method is simple, it has, nevertheless, been productive of great results, by defining, with mathematical precision, the boundaries of lands in the new States, and thus settling their titles on an indisputable basis.

This method was originated by Col. Jared Mansfield, whose great acquirements in science introduced him to the notice of President Jefferson, by whom he was appointed Surveyor-general of the Northwestern Territory, in the early part of the present century.

Among the changes which have been made in the present edition, and which must be very acceptable to Practical Surveyors, are the methods of laying down Railroad Curves, Section Levelling for Excavation and Embankment, and the article on Mining Engineering. For the first of these, I am mainly indebted to Professor Plympton, of the Brooklyn Polytechnic Institute, who has happily combined science and art, both in his methods of teaching and in his practical operations in the field; and for the latter, to Professor Peck, of Columbia College, to whom education and science are indebted for much valuable labor.

Fishkill-on-Hudson, June, 1870.

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ELEMENTS OF SURVEYING.

BOOK I.

LOGARITHMS AND TRIGONOMETRY.

SECTION I.

LOGARITHMS.

1. THE LOGARITHM of a number is the exponent of the power to which it is necessary to raise a fixed number, to produce the given number.

The fixed number is called the *base of the system.* Any positive number, except 1, may be taken as the base of a system. In the common system, the base is 10.

2. If we denote any positive number by n, and the corresponding exponent of 10 by p, we shall have the exponential equation,

$$10^p = n. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

In this equation, p is, by definition, the logarithm of n, which may be expressed thus,

$$p = \log n. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

3. From the definition of a logarithm, it follows that, *the logarithm of any power of* 10 *is equal to the exponent of that power:* hence, the formula,

$$\log (10)^p = \log n = p. \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

If a number is an exact power of 10, its logarithm is a *whole number.*

If a number is not an exact power of 10, its logarithm will not be a whole number, but will be made up of *an entire part* plus *a fractional part,* which is generally expressed decimally. The entire part of a logarithm is called the *characteristic;* the decimal part is called the *mantissa.*

4. If, in Equation (3), we make p successively equal to 0, 1, 2, 3, &c.; and then equal to -1, -2, -3, &c., we may form the following

TABLE.

$\log 1 = 0$	
$\log 10 = 1$	$\log .1 = -1$
$\log 100 = 2$	$\log .01 = -2$
$\log 1000 = 3$	$\log .001 = -3$
&c., &c.	&c., &c.

When a number lies between 1 and 10, its logarithm lies between 0 and 1; that is, it is equal to 0, *plus* a decimal; if a number lies between 10 and 100, its logarithm is equal to 1, *plus* a decimal; if between 100 and 1000, its logarithm is equal to 2, *plus* a decimal; and so on: hence, we have the following

RULE.—*The characteristic of the logarithm of any whole number is positive, and numerically* 1 *less than the number of places of figures in the given number.*

When a decimal fraction lies between .1 and 1, its logarithm lies between -1 and 0, that is, it is equal to -1, *plus* a decimal; if a number lies between .01 and .1, its logarithm is equal to -2, *plus* a decimal; if between .001 and .01, its logarithm is equal to -3, *plus* a decimal; and so on: hence, the following

RULE.—*The characteristic of the logarithm of a decimal fraction is negative, and numerically* 1 *greater than the number of* 0's *that immediately follow the decimal point.*

The characteristic alone is negative, *the mantissa being always positive.* This fact is indicated by writing the negative sign over the characteristic: thus, $\overline{2}.371465$, is equivalent to $-2 + .371465$.

NOTE.—It is to be observed, that the characteristic of a mixed number is the same as that of its entire part. Thus, the mixed number 74.103 lies between 10 and 100; hence, its logarithm lies between 1 and 2, as does the logarithm of 74.

GENERAL PRINCIPLES.

5. Let m and n denote any two numbers, and p and q their logarithms. We shall have, from the definition of a logarithm, the following equations,

$$10^p = m. \quad . \; . \; . \; . \; . \; . \; . \quad (4.)$$
$$10^q = n. \quad . \; . \; . \; . \; . \; . \; . \quad (5.)$$

Multiplying (4) and (5), member by member, we have,

$$10^{p+q} = mn;$$

whence, by the definition,

$$p + q = \log(mn). \quad . \; . \; . \; . \; . \quad (6.)$$

That is, *the logarithm of the product of two numbers is equal to the sum of the logarithms of the numbers.*

6. Dividing (4) by (5), member by member, we have,

$$10^{p-q} = \frac{m}{n};$$

whence, by the definition,

$$p - q = \log\left(\frac{m}{n}\right). \quad . \; . \; . \; . \; . \quad (7.)$$

That is, *the logarithm of a quotient is equal to the logarithm of the dividend diminished by that of the divisor.*

7. Raising both members of (4), to a power denoted by t, we have,

$$10^{pt} = m^t;$$

whence, by the definition,

$$pt = \log m^t. \quad . \quad . \quad . \quad . \quad . \quad . \quad (8.)$$

That is, *the logarithm of any power of a number, is equal to the logarithm of the number multiplied by the exponent of the power.*

8. Extracting the root, indicated by r, of both members of (4), we have,

$$10^{\frac{p}{r}} = \sqrt[r]{m};$$

whence, by the definition,

$$\frac{p}{r} = \log \sqrt[r]{m}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (9.)$$

That is, *the logarithm of any root of a number, is equal to the logarithm of the number divided by the index of the root.*

The preceding principles enable us to abbreviate the operations of multiplication and division of numbers, by the addition and subtraction of their logarithms.

TABLE OF LOGARITHMS.

9. A TABLE OF LOGARITHMS, is a table by means of which we can find the logarithm corresponding to any number, or the number corresponding to any logarithm.

In the table appended, the complete logarithm is given for all numbers from 1 up to 100. For other numbers, between 100 and 10,000, the mantissas alone are given; the characteristic may be found by one of the rules of (Art. 4).

Before explaining the uses of the table, it is to be shown that the mantissa of the logarithm of any number is not changed by multiplying or dividing the number by any exact power of 10.

Let n denote any number whatever, and 10^p any power of 10, p being any whole number, either positive or negative. Then, in accordance with the principles of (Arts. **5** and **3**), we shall have,

$$\log\,(n \times 10^p) = \log n + \log 10^p = p + \log n;$$

but p is, by hypothesis, a whole number; hence, the decimal part of the $\log\,(n \times 10^p)$, is the same as that of $\log n$; *which was to be proved.*

Hence, in finding the mantissa of the logarithm of a number, we may regard the number as a decimal, and move the decimal point to the right or left, at pleasure. Thus, the mantissa of the logarithm of 456357, is the same as that of the number 4563.57; and the mantissa of the logarithm of 2.00357, is the same as that of 2003.57.

EXAMPLES.

log 327	is	2.514548
log 32.7	"	1.514548
log 3.27	"	0.514548
log .327	"	$\bar{1}.514548$
log .0327	"	$\bar{2}.514548$

Using the Table.

1°. To find, from the table, the logarithm of a number less than 100.

10. Look on the first page, in the column headed "N," for the given number; the number opposite is the logarithm required. Thus,

$$\log 67 = 1.826075.$$

2°. To find the logarithm of a number between 100 and 10,000.

11. Find the characteristic by the first rule of (Art. **4**).

To find the mantissa, look in the column headed "N," for the first three figures of the number; then pass along a horizontal line until you come to the column headed with the fourth figure of the number; at this place will be found four figures of the mantissa, to which, two other figures, taken from the column headed "0," are to be prefixed. If the figures found stand opposite a row of six figures, in the column headed "0," the first two of this row are the ones to be prefixed; if not, ascend the column till a row of six figures is found; the first two, of this row, are the ones to be prefixed.

If, however, in passing back from the four figures, first found, any *dots* are passed, the two figures to be prefixed must be taken from the line immediately below. When the figures first found, fall at a place where dots occur, the dots must be replaced by 0's, and the figures to be prefixed must be taken from the *line below*. Thus,

Log 8979 = 3.953228
Log 3098 = 3.491081
Log 2188 = 3.340047

3°. To find the logarithm of a number greater than 10,000.

12. Find the characteristic by the first rule of (Art. **4**).

To find the mantissa, place a decimal point after the fourth figure (Art. **9**), thus converting the number into a mixed number. Find the mantissa of the entire part, by the method last given. Then take from the column headed "D," the corresponding *tabular difference*, and multiply this by the decimal part and add the product to the mantissa just found. The result will be the required mantissa.

It is to be observed that when the decimal part of the product just spoken of is equal to or exceeds .5, we add 1 to the entire part; otherwise the decimal part is rejected.

EXAMPLE.

To find the logarithm of 672887.

The characteristic is 5. Placing a decimal point after the fourth figure, the number becomes 6728.87. The mantissa of the logarithm of 6728 is 827886, and the corresponding number in the column "D," is 65. Multiplying 65 by .87, we have 56.55; or, since the decimal part exceeds .5, 57. We add 57 to the mantissa already found, giving 827943, and we finally have,

$$\log 672887 = 5.827943.$$

The numbers in the column "D" are the differences between the logarithms of two consecutive whole numbers, and are found by subtracting the number under the heading "4" from that under the heading "5."

In the example last given, the mantissa of the logarithm of 6728 is 827886, and that of 6729 is 827951, and their difference is 65; 87 hundredths of this difference is 57: hence, the mantissa of the logarithm of 6728.87, is found by adding 57 to 827886. The principle employed is, that the differences of numbers are proportional to the differences of their logarithms, when these differences are small.

4°. To find the logarithm of a decimal.

13. Find the characteristic by the second rule of (Art. **4**).

To find the mantissa, drop the decimal point, and thus consider the decimal a whole number. Find the mantissa of the logarithm of this number, and it will be the mantissa required. Thus,

$$\log\ .0327 = \bar{2}.514548$$
$$\log\ 378.024 = 2.577520$$

5°. To find the number corresponding to a given logarithm.

14. The rule is the reverse of those just given. Look in the table for the mantissa of the given logarithm. If it cannot be found, take out the next less mantissa, and also the corresponding number, which set aside. Find the difference between the mantissa taken out and that of the given logarithm; annex as many 0's as may be necessary, and divide this result by the corresponding number in the column "D." Annex the quotient to the number set aside, and then point off, from the left hand, a number of places of figures equal to the characteristic plus 1: the result will be the number required.

If the characteristic is negative, the result will be a pure decimal, and the number of 0's which immediately follow the decimal point, will be one less than the number of units in the characteristic.

EXAMPLES.

1. Let it be required to find the number corresponding to the logarithm 5.233568.

The next less mantissa in the table is 233504; the corresponding number is 1712, and the tabular difference is 253.

OPERATION.

Given mantissa, ... 233568
Next less mantissa, ... 233504 . . 1712
253) 6400000 (25296

∴ The required number is 171225.296.

2. What is the number corresponding to the logarithm $\bar{2}.233568$? *Ans.* .0171225.

3. What is the number corresponding to the logarithm $\bar{2}.785407$? *Ans.* .00101084.

4. What is the number corresponding to the logarithm $\bar{1}.846741$? *Ans.* .702653.

MULTIPLICATION BY LOGARITHMS.

15. From the principle proved in (Art. **5**), we deduce the following

RULE.—*Find the logarithms of the factors, and take their sum; then find the number corresponding to the resulting logarithm, and it will be the product required.*

EXAMPLES.

1. Multiply 23.14 by 5.062.

OPERATION.

log 23.14 . . . 1.364363
log 5.062 . . . 0.704322
2.068685 $\therefore$ 117.1347, product.

2. Find the continued product of 3.902, 597.16, and 0.0314728.

OPERATION.

log 3.902 . . . 0.591287
log 597.16 . . . 2.776091
log 0.0314728 . . . $\bar{2}.497936$
1.865314 $\therefore$ 73.3354, product.

Here, the $\bar{2}$ cancels the + 2, and the 1 carried from the decimal part is set down.

3. Find the continued product of 3.586, 2.1046, 0.8372, and 0.0294. *Ans.* 0.1857615.

DIVISION BY LOGARITHMS.

16. From the principle proved in (Art. **6**), we have the following

RULE.—*Find the logarithms of the dividend and divisor, and subtract the latter from the former; then find the number corresponding to the resulting logarithm, and it will be the quotient required.*

EXAMPLES.

1. Divide 24163 by 4567.

OPERATION.

$$\begin{array}{lll} \log 24163 \;\ldots & 4.383151 & \\ \log \;\; 4567 \;\ldots & 3.659631 & \\ \cline{2-2} & 0.723520 & \therefore\; 5.29078, \text{ quotient.} \\ \cline{2-2} \end{array}$$

2. Divide 0.7438 by 12.9476.

OPERATION.

$$\begin{array}{lll} \log \;\; 0.7438 \;\ldots & \bar{1}.871456 & \\ \log 12.9476 \;\ldots & 1.112189 & \\ \cline{2-2} & \bar{2}.759267 & \therefore\; 0.057447, \text{ quotient.} \\ \cline{2-2} \end{array}$$

Here, 1 taken from $\bar{1}$, gives $\bar{2}$ for a result. The subtraction, as in this case, is always to be performed in the algebraic sense.

3. To divide 0.06314 by .007241.

$$\begin{array}{lll} \log \;\; 0.06314 \;\ldots & \bar{2}.800305 & \\ \log 0.007241 \;\ldots & \bar{3}.859799 & \\ \cline{2-2} & 0.940506 & \therefore\; 8.7198, \text{ quotient.} \\ \cline{2-2} \end{array}$$

Here, 1 carried from the decimal part to the $\bar{3}$, changes it to $\bar{2}$, which being taken from $\bar{2}$, leaves 0 for the characteristic.

4. To divide 37.149 by 523.76.

log 37.149 . .	1.569947
log 523.76 . . .	2.719133
	$\bar{2}.850814$ ∴ 0.0709274, quotient.

5. Divide 0.7438 by 12.9476.

Ans. 0.057447.

The operation of division, particularly when combined with that of multiplication, can often be simplified by using the principle of

ARITHMETICAL COMPLEMENT.

17. The ARITHMETICAL COMPLEMENT of a logarithm is the remainder obtained by subtracting it from 10. Thus, 8.130456 is the arithmetical complement of 1.869544. The arithmetical complement of a logarithm may be written out *by commencing at the left hand and subtracting each figure from* 9, *until the last significant figure is reached, which must be taken from* 10. The arithmetical complement is denoted by the symbol (a. c.).

Let a and b represent any two logarithms whatever, and $a - b$ their difference. Since we may add 10 to, and subtract it from, $a - b$, without altering its value, we have,

$$a - b = a + (10 - b) - 10. \quad . \quad . \quad . \quad (10.)$$

But, $10 - b$ is, by definition, the arithmetical complement of b: hence, Equation (10) shows that the difference between two logarithms is equal to *the first,* plus *the arithmetical complement of the second,* minus 10.

Hence, to divide one number by another by means of the arithmetical complement, we have the following

RULE.—*Find the logarithm of the dividend, and the arithmetical complement of the logarithm of the divisor, add them together, and diminish the sum by* 10; *the number corresponding to the resulting logarithm will be the quotient required.*

EXAMPLES.

1. Divide 327.5 by 22.07.

OPERATION.

$$\begin{array}{lr} \text{log } 327.5 \;.\;.\;. & 2.515211 \\ \text{(a. c.) log } 22.07 \;.\;.\;. & 8.656198 \\ \hline & 1.171409 \end{array} \quad \therefore\ 14.839, \text{ quotient.}$$

2. Divide 0.7438 by 12.9476.

$$\begin{array}{lr} \text{log } 0.7438 \;.\;.\;. & \bar{1}.871456 \\ \text{(a. c.) log } 12.9476 \;.\;.\;. & 8.887811 \\ \hline & \bar{2}.759267 \end{array} \quad \therefore\ 0.057447, \text{ quotient.}$$

In this example, the sum of the characteristics is 8, from which, taking 10, the remainder is $\bar{2}$.

3. Divide 37.149 by 523.76.

$$\begin{array}{lr} \text{log } 37.149 \;.\;.\;. & 1.569947 \\ \text{(a. c.) log } 523.76 \;.\;.\;. & 7.280867 \\ \hline & \bar{2}.850814 \end{array} \quad \therefore\ 0.0709273, \text{ quotient.}$$

4. Multiply 358884 by 5672, and divide the product by 89721.

OPERATION.

log 358884 . . . 5.554954
log 5672 . . . 3.753736
(a. c.) log 89721 . . . 5.047106
4.355796 $\therefore$ 22688, result.

5. Find x in the proportion,

$$3976 : 7952 :: 5903 : x.$$

OPERATION.

(a. c.) log 3976 . . . 6.400554
log 7952 . . . 3.900476
log 5903 . . . 3.771073
log x . . . 4.072103 $\therefore$ $x = 11806$.

The operation of subtracting 10 is always performed mentally.

NOTE 1.—In finding any term of a proportion by logarithms —observe that,

1. *The sum of the logarithms of the extremes, is equal to the sum of the logarithms of the means:*

2. *The logarithm of the fourth term, is equal to the arithmetical complement of the logarithm of the first term added to the logarithms of the mean terms:*

3. *The logarithm of either mean term, is equal to the arithmetical complement of the logarithm of the other mean added to the logarithms of the extremes.*

NOTE 2.—If any proportion, as

$$a : b :: c : x,$$

be changed into the form of an equation, thus,

$$ax = bc, \qquad \text{then}$$

(a. c.) $\log a + \log b + \log c - 10 = \log x$; that is, *The arithmetical complement of the logarithm of the multiplier of the unknown factor, plus the logarithms of the two other factors, minus* 10, *is equal to the logarithm of the unknown factor.*

NOTE 3.—If the logarithm, whose arithmetical complement is taken, exceeds 10, subtract it from 20, and reject 20 in the final operation.

RAISING TO POWERS BY LOGARITHMS.

18. To raise a number to any power. From the principle proved in (Art. **7**), we have the following

RULE.—*Find the logarithm of the number, and multiply it by the exponent of the power; then find the number corresponding to the resulting logarithm, and it will be the power required.*

EXAMPLES.

1. Find the 5th power of 9.

$$\begin{array}{lr} \log 9 \quad . \quad . \quad . & 0.954243 \\ & 5 \\ \hline & 4.771215 \quad \therefore \quad 59049, \text{ power.} \end{array}$$

2. Find the 7th power of 8. *Ans.* 2097152.

EXTRACTING ROOTS BY LOGARITHMS.

19. To find any root of a number, from the principle proved in (Art. **8**), we have the following

RULE.—*Find the logarithm of the number, and divide it by the index of the root; then find the number corresponding to the resulting logarithm, and it will be the root required.*

EXAMPLE.

1. Find the cube root of 4096.

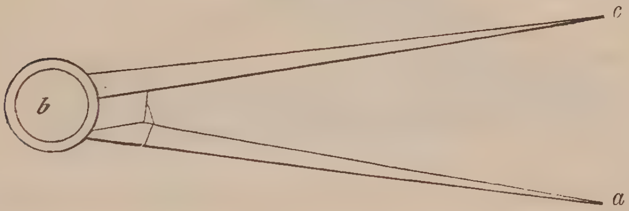
The logarithm of 4096 is 3.612360, and one-third of this is 1.204120. The corresponding number is 16, which is the root sought.

SECTION II.

GEOMETRICAL CONSTRUCTIONS.

20. Before explaining the method of constructing geometrical problems, we shall describe some of the simpler instruments and their uses.

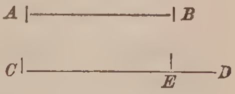
DIVIDERS.



21. The dividers is the most simple and useful of the instruments used for drawing. It consists of two legs *ba*, *bc*, which may be easily turned around a joint at *b*.

One of the principal uses of this instrument is to lay off on a line, a distance equal to a given line.

For example, to lay off on CD, a distance equal to AB.



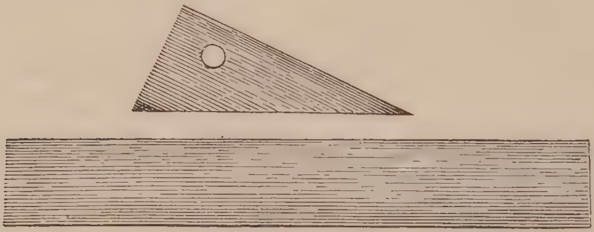
For this purpose, place the forefinger on the joint of the dividers, and set one foot at *A:* then extend, with the thumb and other fingers, the other leg of the dividers, until its foot reaches the point *B*. Then raise the dividers, place one foot at *C*, and mark with the other the distance *CE:* this will evidently be equal to *AB*.

RULER AND TRIANGLE.

22. A Ruler of convenient size is about twenty inches in length, two inches wide, and a fifth of an inch in thickness.

It should be made of a hard material, perfectly straight and smooth.

The hypothenuse of the right-angled triangle, which is used in connection with it, should be about ten inches in length, and it is most convenient to have one of the sides considerably longer than the other.

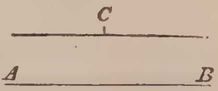


We can solve, with the ruler and triangle, the two following problems.

I. To draw through a given point a line which shall be parallel to a given line.

23. Let C be the given point, and AB the given line.

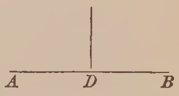
Place the hypothenuse of the triangle against the edge of the ruler, and then place the ruler and triangle on the paper, so that one of the sides of the triangle shall coincide exactly with AB: the triangle being below the line.



Then, placing the thumb and fingers of the left hand firmly on the ruler, slide the triangle, with the other hand, along the ruler, until the side which coincided with AB reaches the point C. Leaving the thumb of the left hand on the ruler, extend the fingers upon the triangle and hold it firmly, and with the right hand, mark with a pen or pencil, a line through C: this line will be parallel to AB.

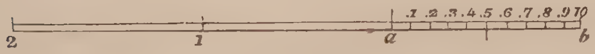
II. To draw through a given point a line which shall be perpendicular to a given line.

24. Let *AB* be the given line, and *D* the given point.



Place the hypothenuse of the triangle against the edge of the ruler, as before. Then place the ruler and triangle so that one of the sides of the triangle shall coincide exactly with the line *AB*. Then slide the triangle along the ruler until the other side reaches the point *D:* then, draw through *D*, a right line, and it will be perpendicular to *A B*.

SCALE OF EQUAL PARTS.



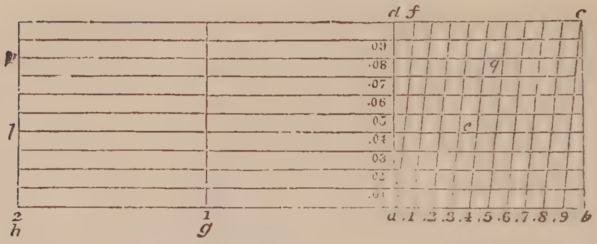
25. A scale of equal parts is formed by dividing a line of a given length, into equal portions.

If, for example, the line *ab*, of a given length, say one inch, be divided into any number of equal parts, as 10, the scale thus formed is called a scale of *ten parts to the inch*. The line *ab*, which is divided, is called the *unit of the scale.* This unit is laid off several times on the left of the divided line, and the points marked 1, 2, 3, &c.

The unit of scales of equal parts is, in general, either an inch, or an exact part of an inch. If, for example, *ab*, the unit of the scale, were half an inch, the scale would be one of 10 parts to half an inch, or of 20 parts to the inch.

If it were required to take from the scale a line equal to two inches and six-tenths, place one foot of the dividers at 2, on the left, and extend the other to .6, which marks the sixth of the small divisions: the dividers will then embrace the required distance.

DIAGONAL SCALE OF EQUAL PARTS.



26. This scale is thus constructed. Take *ab* for the unit of the scale, which may be one inch, $\frac{1}{2}$, $\frac{1}{4}$, or $\frac{3}{4}$ of an inch, in length. On *ab* describe the square *abcd.* Divide the sides *ab* and *dc* each into ten equal parts. Draw *af*, and the other nine parallels as in the figure.

Produce *ba*, to the left, and lay off the unit of the scale any convenient number of times, and mark the points 1, 2, 3, &c. Then, divide the line *ad* into ten equal parts, and through the points of division draw parallels to *ab*, as in the figure.

Now, the small divisions of the line *ab* are each one-tenth (.1) of *ab*; they are therefore .1 of *ad*, or .1 of *ag* or *gh*.

If we consider the triangle *adf*, we see, that the base *df* is one-tenth of *ad*, the unit of the scale. Since the distance from *a* to the first horizontal line above *ab* is one-tenth of the distance *ad*, it follows that the distance measured on that line, between *ad* and *af*, is one-tenth of *df:* but since one-tenth of a tenth is a hundredth, it follows that this distance is one hundredth (.01) of the unit of the scale. A like distance, measured on the second line, is two hundredths (.02) of the unit of the scale; on the third, .03; on the fourth, .04, &c.

If it were required to take, in the dividers, the unit of the scale, and any number of tenths, place one foot of the dividers at 1, and extend the other to that figure between *a* and *b* which designates the tenths. If two or more units are required, the dividers must be placed on a point of division farther to the left.

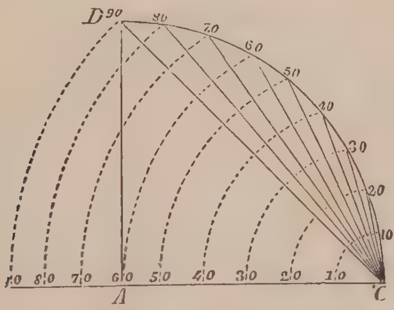
When units, tenths, and hundredths are required, place one foot of the dividers where the vertical line through the point which designates the units, intersects the line which designates the hundredths: then, extend the dividers to that line between *ad* and *bc* which designates the tenths: the distance so embraced will be the one required.

For example, to take off the distance 2.34, we place one foot of the dividers at *l*, and extend the other to *e:* and to take off the distance 2.58, we place one foot of the dividers at *p* and extend the other to *q*.

Note 1.—If a line is so long that the whole of it cannot be taken from the scale, it must be divided, and the parts of it taken from the scale in succession.

Note 2.—If a line be given upon the paper, its length can be found by taking it in the dividers and applying it to the scale.

SCALE OF CHORDS.



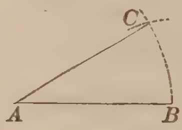
27. If, with any radius, as *AC*, we describe the quadrant *CD*, and then divide it into 90 equal parts, each part is called a degree.

If through *C*, and each point of division, a chord be drawn, and the lengths of these chords be accurately laid off on a scale; such a scale is called a *scale of chords.* In the figure, the chords are drawn for every ten degrees.

The scale of chords being once constructed, the radius of the circle from which the chords were obtained, is known; for, the chord marked 60, is always equal to the radius of the circle. A scale of chords is generally laid down on the scales which belong to cases of mathematical instruments, and is marked CHO.

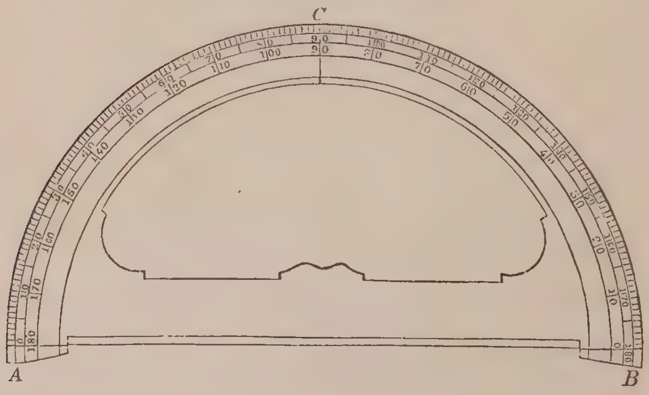
III. To lay off, at a given point of a line, with the scale of chords, an angle equal to a given angle.

28. Let AB be the line, and A the given point.



Take from the scale the chord of 60 degrees, and with this radius and the point A as a centre, describe the arc BC. Then take, from the scale, the chord of the given angle, say 30 degrees, and with this distance as a radius, and B as a centre, describe an arc cutting BC in C. Through A and C, draw the line AC, and BAC will be the required angle.

SEMICIRCULAR PROTRACTOR.



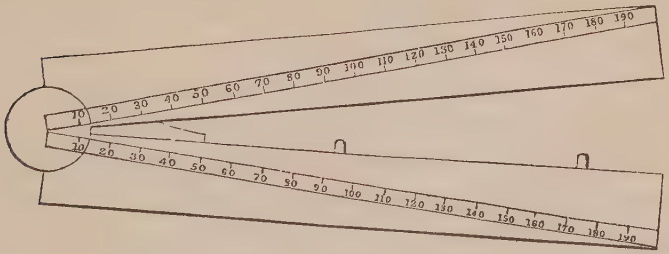
29. This instrument is used to lay down, or protract angles. It may also be used to measure angles included between lines, already drawn upon paper.

It consists of a brass semicircle, *ABC*, divided to half degrees. The degrees are numbered from 0 to 180, both ways; that is, from *A* to *B* and from *B* to *A*. The divisions, in the figure, are made only to degrees. There is a small notch at the middle of the diameter *AB*, which indicates the centre of the protractor.

IV. To lay off an angle with a Protractor.

30. Place the diameter *AB* on the line, so that the centre shall fall on the angular point. Then count the degrees contained in the given angle, from *A* toward *B*, or from *B* toward *A*, and mark the extremity of the arc with a pin. Remove the protractor, and draw a line through the point so marked, and the angular point: this line will make with the given line the required angle.

SECTORAL SCALE OF EQUAL PARTS.



31. The sector is an instrument generally made of ivory or brass. It consists of two arms, or sides, which open, by turning round a joint, at their common extremity.

There are several scales laid down on the sector: those, however, which are chiefly used in drawing lines and angles, are, the scale of chords already described, and the scale of equal parts now to be explained.

On each arm of the sector, there is a diagonal line that passes through the point about which the arms turn: these diagonal lines are divided into equal parts.

On the sectors which belong to the cases of English instruments, the diagonal lines are designated by the letter *L*, and numbered from the centre of the sector, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, to the two extremities. On the sectors which belong to cases of French instruments, they are designated, "Les parties égales," and numbered 10, 20, 30, 40, &c., to 200. On the English sectors there are 20 equal divisions between any two of the lines numbered 1, 2, 3, &c., so that there are 200 equal parts on the scale.

The advantage of the sectoral scale of equal parts, is this:

Let it be proposed to draw a line upon paper, on such a scale that any number of parts of the line, 40 for example, shall be represented by one inch on the paper, or by any part of an inch. Take the inch, or part of the inch, from the scale of inches, on the sector; then, placing one foot of the dividers at 40, on one arm of the sector, open the sector until the other foot reaches to the corresponding number on the other arm: then, lay the sector on the table without varying the angle.

Now, if we regard the lines on the sector as the two sides of a triangle, of which the line 40, measured across, is the base, it is plain, that if any other line be likewise measured across the angle of the sector, the bases of the triangles, so formed, will be proportional to their sides. Therefore, if we extend the dividers from 50 to 50, this distance will represent a line of 50, to the given scale: and similarly for other lines.

V. Required to lay down a line of sixty-seven feet, to a scale of twenty feet to the inch.

Take one inch from the scale of inches: then place one foot of the dividers at the twentieth division, and open the sector until the dividers will just reach the twentieth division on the other arm: the sector is then set to the proper angle; after which the required distance to be laid down on the paper is found by extending the dividers from the sixty-seventh division on one arm, to the sixty-seventh division on the other.

GUNTER'S SCALE.

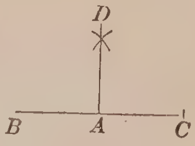
32. This is a scale of two feet in length, on the faces of which several scales are marked. The face on which the divisions of inches are made, contains, however, all the scales necessary for laying down lines and angles. These are, the scale of equal parts, the diagonal scale of equal parts, and the scale of chords, all of which have been described.

SOLUTION OF PROBLEMS.

I. At a given point, in a given straight line, to erect a perpendicular to the line.

33. Let *A* be the given point, and *BC* the given line.

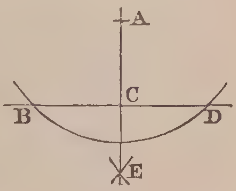
From *A*, lay off any two distances, *AB* and *AC*, equal to each other. Then, from the points *B* and *C*, as centres, with a radius greater than *BA*, describe two arcs intersecting each other at *D:* draw *AD*, and it will be the perpendicular required.



II. From a given point, without a straight line, to let fall a perpendicular on the line.

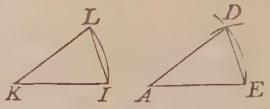
34. Let *A* be the given point, and *BD* the given line.

From the point *A*, as a centre, with a radius sufficiently great, describe an arc cutting the line *BD* in the two points *B* and *D:* then, mark a point *E*, equally distant from the points *B* and *D*, and draw *AE:* *AE* will be the perpendicular required.



III. At a point, in a given line, to make an angle equal to a given angle.

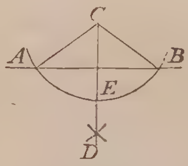
35. Let *A* be the given point, *AE* the given line, and *IKL* the given angle.



From the vertex *K*, as a centre, with any radius, describe the arc *IL*, terminating in the two sides of the angle. From the point *A*, as a centre, with a distance *AE*, equal to *KI*, describe the arc *ED;* then take the chord *LI*, with which, from the point *E* as a centre, describe an arc cutting the indefinite arc *DE*, in *D;* draw *AD*, and the angle *EAD* will be equal to the given angle *K*.

IV. To divide a given angle, or a given arc, into two equal parts.

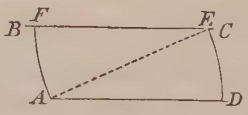
36. Let *ACB* be the given angle, and *AEB* the arc which measures it.



From the points *A* and *B* as centres, describe, with the same radius, two arcs cutting each other in *D:* through *D* and the centre *C* draw *CD:* the angle *ACE* will be equal to the angle *ECB*, and the arc *AE* to the arc *EB*.

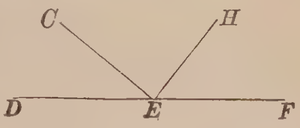
V. Through a given point, to draw a parallel to a given line.

37. Let *A* be the given point, and *BC* the given line.



From *A* as a centre, with a radius greater than the shortest distance from *A* to *BC*, describe the indefinite arc *ED*. Then, from the point *E* as a centre, with the same radius, describe the arc *AF;* make *ED* = *AF*, and draw *AD:* then will *AD* be the parallel required.

VI. Two angles of a triangle being given, to find the third.



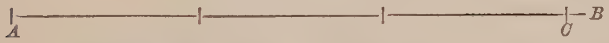
38. Draw the indefinite line *DEF*. At the point *E*, make the angle *DEC* equal to one of the given angles, and the angle *CEH* equal to the other: the remaining angle *HEF* will be the third angle required.

VII. To represent, on paper, a line of a given length, so that any number of its parts shall correspond to the unit of the scale.

39. Suppose that the given line were 75 feet in length, and it were required to draw it on paper, on a scale of 25 feet to the inch.

The length of the line, 75 feet, being divided by 25, will give 3, the number of inches which will represent the line on paper.

Therefore, draw the indefinite line *AB*, on which lay off from *C*, a distance *AC* equal to 3 inches: *AC* will represent the given line of 75 feet, drawn to the required scale.



NOTE.—This problem explains the manner of representing a line upon paper, so that a given number of its parts shall correspond to the unit of the scale, whether that unit be an inch or any part of an inch.

When the length of the line to be laid down is given, and it has been determined how many parts of it are to be represented on the paper by a distance equal to the unit of the scale, we find the length which is to be taken from the scale by the following

RULE.—*Divide the length of the line by the number of parts which is to be represented by the unit of the scale: the quotient will show the number of units which is to be taken from the scale.*

EXAMPLES.

1. If a line of 640 feet is to be laid down on paper, on a scale of 40 feet to the inch; what length must be taken from the scale? 40) 640 (16 inches.

2. If a line of 357 feet is to be laid down on a scale of 68 feet to the unit of the scale (which we will suppose half an inch), how many parts are to be taken?

Ans. $\begin{cases} 5.25 \text{ parts, or} \\ 2.625 \text{ inches.} \end{cases}$

3. A line of 384 feet is drawn on paper, on a scale of 45 feet to the inch; what is its length on the paper?

Ans. 8.53 inches.

NOTE.—When the length of a line on the paper is given, and it is required to find the true length of the line which it represents, take the line in the dividers and apply it to the scale, and note the number of units, and parts of a unit, to which it is equal. Then multiply this number by the number of parts which the unit of the scale represents, and the product will be the length of the line.

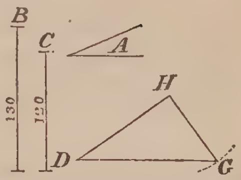
For example, suppose the length of a line drawn on the paper was found to be 3.55 inches, the scale being 40 feet to the inch: then,

$$3.55 \times 40 = 142 \text{ feet, the length of the line.}$$

VIII. Having given two sides and the included angle of a triangle, to describe the triangle.

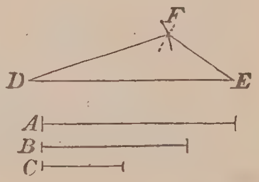
40. Let the line $B = 150$ feet, and $C = 120$ feet, be the given sides; and $A = 30$ degrees, the given angle: to describe the triangle on a scale of 200 feet to the inch.

Draw the indefinite line DG, and at the point D, make the



angle *GDH* equal to 30 degrees: then lay off *DG* equal to 150 feet, equal to three-quarters of an inch, and *DH* equal to 120 feet, equal to six-tenths of an inch, and draw *GH*: then, *DHG* will be the required triangle.

IX. The three sides of a triangle being given, to describe the triangle.

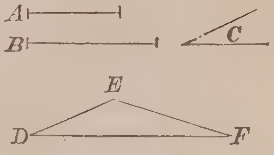


41. Let *A*, *B* and *C* be the sides.

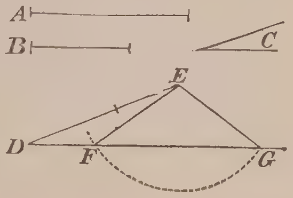
Make *DE* equal to the side *A*. From the point *D* as a centre, with a radius equal to the second side *B*, describe an arc: from *E* as a centre, with a radius equal to the third side *C*, describe another arc, intersecting the former in *F*; draw *DF* and *EF*, and *DFE* will be the triangle required.

X. Having given two sides of a triangle and an angle opposite one of them, to describe the triangle.

42. Let *A* and *B* be the given sides, and *C* the given angle, which we will suppose to be opposite the side *B*.



Draw the indefinite line *DF*: then, at any point of it, as *D*, make the angle *FDE* equal to the angle *C*: take *DE* = *A*, and from the point *E*, as a centre, with a radius equal to the other given side, *B*, describe an arc, cutting *DF* in *F*; draw *EF*: then will *DEF* be the required triangle.

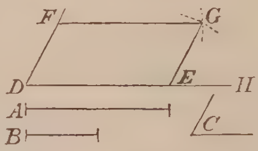


If the angle *C* is acute, and the side *B* less than *A*, then the arc described from the centre *E* with the radius *EF* = *B* will cut the side *DF* in two points, *F* and *G*, lying on the same side of *D*: hence, there will be two triangles, *DEF* and *DEG*, either of which will satisfy all the conditions of the problem.

XI. The adjacent sides of a parallelogram, with the angle which they contain, being given, to describe the parallelogram.

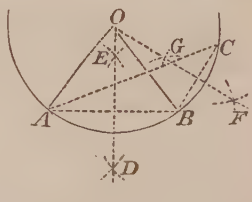
43. Let *A* and *B* be the given sides, and *C* the given angle.

Draw the line *DH*, and lay off *DE* equal to *A*; at the point *D*, make the angle $EDF = C$; take $DF = B$: describe two arcs, the one from *F*, as a centre, with a radius $FG = A$, the other from *E*, as a centre, with a radius $EG = BF$; through the point *G*, where these arcs intersect each other, draw *FG*, *EG*: then, *DEGF* will be the parallelogram required.



XII. To find the centre of a given circle, or arc.

44. Take three points, *A*, *B*, *C*, anywhere in the circumference, or in the arc: draw *AB*, *BC*; bisect these two lines by the perpendiculars, *DE*, *FG*: the point *O*, where these perpendiculars meet, will be the centre sought.



A similar construction serves for making a circumference pass through three given points, *A*, *B*, *C*, and also for describing a circumference, about a given triangle.

For, if we join the points by the straight lines *AB*, *BC*, and *AC*, and bisect either two of them, by perpendiculars, their point of intersection, *O*, will be the centre of the required circle.

SECTION III.

PLANE TRIGONOMETRY

45. Plane Trigonometry is that branch of Mathematics which treats of the *solution* of plane triangles.

In every plane triangle there are six parts: *three sides* and *three angles.* When three of these parts are given, one being a side, the remaining parts may be found by computation.

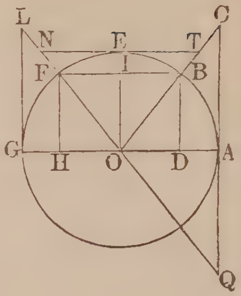
46. An angle is measured by the arc of a circle included between its sides, the centre of the circle being at the vertex, and its radius being equal to 1.

47. If two lines be drawn through the centre of a circle, at right angles to each other, they will divide the circumference into four equal parts, each of which is called a quadrant.

For convenience, the quadrant is divided into 90 equal parts, each of which is called *a degree;* each degree into 60 equal parts, called *minutes;* and each minute into 60 equal parts, called *seconds.* Degrees, minutes, and seconds, are denoted by the symbols °, ′, ″. Thus, the expression 7° 22′ 33″ is read, *7 degrees, 22 minutes,* and 33 *seconds.*

A quadrant contains 324,000 seconds, and an arc of 7° 22′ 33″ contains 26,553 seconds; and any arc of a quadrant may be expressed in seconds.

48. The *complement* of an arc is what remains after subtracting the arc from 90°. Thus, the arc EB is the complement of AB.



49. The *supplement* of an arc is what remains after subtracting the arc from 180°. Thus, *GF* is the supplement of the arc *AEF.*

50. The *sine* of an arc is the perpendicular let fall from one extremity of the arc on the diameter which passes through the other extremity. Thus, *BD* is the sine of the arc *AB.*

51. The *cosine* of an arc is the part of the diameter intercepted between the foot of the sine and centre. Thus, *OD* is the cosine of the arc *AB.*

52. The *tangent* of an arc is the line which touches it at one extremity, and limited by a line drawn through the other extremity and the centre of the circle. Thus, *AC* is the tangent of the arc *AB.*

53. The *secant* of an arc is the line drawn from the centre of the circle through one extremity of the arc, and limited by the tangent passing through the other extremity. Thus, *OC* is the secant of the arc *AB.*

54. The four lines, *BD, OD, AC, OC,* depend for their values on the arc *AB* and the radius *OA;* they are thus written:

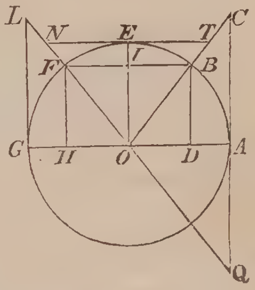
For *BD,* we write . . . . . . sin *AB*
For *OD* " " . . . . . . cos *AB*
For *AC* " " . . . . . . tan *AB*
For *OC* " " . . . . . . sec *AB*

55. If *ABE* be a quadrant, or 90°, then *EB* will be the complement of *AB.* Let the lines *ET* and *IB* be drawn perpendicular to *OE.* Then,

ET, the tangent of EB, is called the cotangent of AB;
IB, the sine of EB, is the cosine of AB;
OT, the secant of EB, is the cosecant of AB.

In general, if A is any arc or angle, we have,

$$\begin{aligned} \cos\ A &= \sin\ (90^\circ - A) \\ \cot\ A &= \tan\ (90^\circ - A) \\ \operatorname{cosec}\ A &= \sec\ (90^\circ - A) \end{aligned}$$



56. If we take an arc, $ABEF$, greater than 90°, its sine will be FH; OH will be its cosine; AQ its tangent, and OQ its secant. But FH is the sine of the arc GF, which is the supplement of AF, and OH is its cosine; hence, *the sine of an arc is equal to the sine of its supplement; and the cosine of an arc is equal to the cosine of its supplement.*[*]

Furthermore, AQ is the tangent of the arc AF, and OQ is its secant: GL is the tangent, and OL the secant of the supplemental arc GF. But since AQ is equal to GL, and OQ to OL, it follows that, *the tangent of an arc is equal to the tangent of its supplement; and the secant of an arc is equal to the secant of its supplement.*[*]

TABLE OF NATURAL SINES.

57. A NATURAL SINE, COSINE, TANGENT, or COTANGENT, is the sine, cosine, tangent, or cotangent of an arc whose radius is 1.

A TABLE OF NATURAL SINES is, therefore, a table showing the values of the sines, cosines, tangents, and cotangents of all the arcs of a quadrant, divided either to minutes or seconds. The Table of Natural Sines, beginning at page 63, of the tables, shows the values of the sines and cosines only.

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[*] These relations are between the *numerical values* of the trigonometrical lines; the algebraic signs, which they have in the different quadrants, are not considered.

TABLE OF LOGARITHMIC SINES.

58. In this table are arranged the logarithms of the numerical values of the sines, cosines, tangents, and cotangents of all the arcs of a quadrant, calculated to a radius of 10,000,000,000. The logarithm of this radius is 10. In the first and last horizontal lines of each page, are written the degrees whose sines, cosines, &c., are expressed on the page. The vertical columns on the left and right are columns of minutes.

To find, in the table, the logarithmic sine, cosine, tangent, or cotangent of any given angle.

59. If the angle is less than 45°, look for the degrees in the first horizontal line of the different pages: when the degrees are found, descend along the column of minutes, on the left of the page, till you reach the number showing the minutes: then pass along a horizontal line till you come into the column designated, sine, cosine, tangent, or cotangent, as the case may be: the number so indicated is the logarithm sought. Thus, on page 37, for 19° 55′, we find,

sine 19° 55′	9.532312
cos 19° 55′	9.973215
tan 19° 55′	9.559097
cot 19° 55′	10.440903

If the angle is greater than 45°, search for the degrees along the bottom line of the different pages: when the number is found, ascend along the column of minutes on the right-hand side of the page, till you reach the number expressing the minutes: then pass along a horizontal line into the column designated tang, cot, sine, or cosine, as the case may be: the number so pointed out is the logarithm required.

60. The column designated sine, at the top of the page, is designated by cosine at the bottom: the one designated tang, by cotang, and the one designated cotang, by tang.

The angle found by taking the degrees at the top of the page, and the minutes from the left-hand vertical column, is the complement of the angle found by taking the degrees at the bottom of the page, and the minutes from the right-hand column on the same horizontal line with the first. Therefore, sine, at the top of the page, should correspond with cosine, at the bottom; cosine with sine, tang with cotang, and cotang with tang, as in the tables.

If the angle is greater than 90°, we have only to subtract it from 180°, and take the sine, cosine, tangent, or cotangent of the remainder, or supplement.

Column of Differences.

61. The column of the table next to the column of sines, and on the right of it, is designated by the letter *D*. This column is calculated in the following manner:

Opening the table at any page, as 42, the sine of 24° is found to be 9.609313; that of 24° 1′, 9.609597: their difference is 284; this being divided by 60, the number of seconds in a minute, gives 4.73, which is entered in the column *D*.

Now, supposing the increase of the logarithmic sine to be proportional to the increase of the arc, and it is nearly so for 60″, it follows, that 4.73 is the increase of the sine for 1″. Similarly, if the arc were 24° 20′, the increase of the sine for 1″ would be 4.65.

The same remarks are applicable in respect of the column *D*, after the column cosine, and of the column *D*, between the tangents and cotangents. The column *D*, between the columns tangents and cotangents, answers to both of these columns.

Now, if it were required to find the logarithmic sine of an arc expressed in degrees, minutes, and seconds, we have only to find the degrees and minutes as before; then, multiply the corresponding tabular difference by the seconds, and add the product to the number first found, for the sine of the given arc.

Thus, if we wish the sine of 40° 26′ 28″.

The sine 40° 26′ 9.811952
Tabular difference 2.47 . . . .
Number of seconds 28 . . . .
Product . . 69.16 to be added, 69.16
Gives for the sine of 40° 26′ 28″, 9.812021.

The decimal figures at the right are generally omitted in the last result; but when they exceed five-tenths, the figure on the left of the decimal point is increased by 1; the logarithm obtained is then exact, to within less than one unit of its right-hand place.

The tangent of an arc, in which there are seconds, is found in a manner entirely similar. In regard to the cosine and cotangent, it must be remembered, that they increase while the arcs decrease, and decrease as the arcs are increased; consequently, the proportional numbers found for the seconds, must be subtracted, not added.

EXAMPLES.

1. To find the cosine of 3° 40′ 40″.

The cosine of 3° 40′ 9.999110
Tabular difference .13 . . . . . .
Number of seconds 40 . . . .
Product . . 5.20 to be subtracted, 5.20
Gives for the cosine of 3° 40′ 40″ . . 9.999105.

2. Find the tangent of 37° 28′ 31″. *Ans.* 9.884592.

3. Find the cotangent of 87° 57′ 59″. *Ans.* 8.550356.

To find the degrees, minutes, and seconds answering to any given logarithmic sign, cosine, tangent, or cotangent.

62. Search in the table, in the proper column, and if the number is found exactly, the degrees will be shown either at the top or bottom of the page, and the minutes in the side column, either at the left, or right.

But, if the number cannot be found in the table, take from the table the degrees and minutes answering to the nearest less logarithm, the logarithm itself, and also the corresponding tabular difference. Subtract the logarithm taken from the table from the given logarithm, annex two ciphers to the remainder, and then divide the remainder by the tabular difference: the quotient will be seconds, and is to be connected with the degrees and minutes before found: to be *added* for the sine and tangent, and *subtracted* for the cosine and cotangent.

EXAMPLES.

1. Find the arc answering to the sine 9.880054
Sine 49° 20′, next less in the table 9.879963
Tabular difference . . . . . 1.81) 91.00 (50″.

Hence, the arc 49° 20′ 50″ corresponds to the given sine 9.880054.

2. Find the arc whose cotangent is 10.008688
cot 44° 26′, next less in the table 10.008591
Tabular difference . . . . . 4.21) 97.00 (23″.

Hence, 44° 26′ − 23″ = 44° 25′ 37″ is the arc answering to the given cotangent, 10.008688.

3. Find the arc answering to tangent, 9.979110.

Ans. 43° 37′ 21″.

4. Find the arc answering to cosine, 9.944599.

Ans. 28° 19′ 45″.

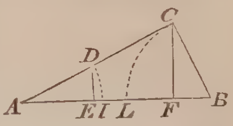
THEOREM I.

The sides of a plane triangle are proportional to the sines of their opposite angles.

63. Let ABC be a triangle; then will

$$CB : CA :: \sin A : \sin B.$$

For, with A as a centre, and AD equal to the less side BC, as a radius, describe the arc DI: and with B as a centre and the equal radius BC, describe the arc CL, and draw DE and CF perpendicular to AB: now DE is the sine of the angle A, and CF is the sine of B, to the same radius AD or BC. But by similar triangles,



$$AD : DE :: AC : CF.$$

But AD being equal to BC, we have

$$BC : \sin A :: AC : \sin B, \quad \text{or}$$

$$BC : AC :: \sin A : \sin B.$$

By comparing the sides AB, AC, in a similar manner, we should find,

$$AB : AC :: \sin C : \sin B.$$

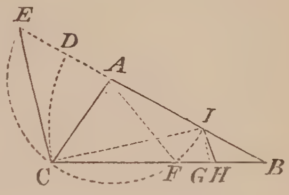
THEOREM II.

In any triangle, the sum of the two sides containing either angle, is to their difference, as the tangent of half the sum of the two other angles, to the tangent of half their difference.

64. Let ACB be a triangle: then will

$$AB + AC : AB - AC :: \tan \tfrac{1}{2}(C + B) : \tan \tfrac{1}{2}(C - B).$$

With A as a centre, and a radius AC, the less of the two given sides, let the semicircumference $IFCE$ be described, meeting AB in I, and BA produced, in E. Then, BE will be the sum of the sides, and BI their difference. Draw CI and AF.



Since CAE is an outward angle of the triangle ACB, it is equal to the sum of the inward angles C and B (Bk. I., Prop. XXV., Cor. 6). But the angle CIE being at the circumference, is half the angle CAE at the centre (Bk. III., Prop. XVIII.); that is, half the sum of the angles C and B, or equal to $\frac{1}{2}(C + B)$.

The angle $AFC = ACB$, is also equal to $ABC + BAF$; therefore, $BAF = ACB - ABC$.

But, $ICF = \frac{1}{2}(BAF) = \frac{1}{2}(ACB - ABC)$, or $\frac{1}{2}(C - B)$.

With I and C as centres, and the common radius IC, let the arcs CD and IG be described, and draw the lines CE and IH perpendicular to IC. The perpendicular CE will pass through E, the extremity of the diameter IE, since the right angle ICE must be inscribed in a semicircle.

But CE is the tangent of $CIE = \frac{1}{2}(C + B)$; and IH is the tangent of $ICB = \frac{1}{2}(C - B)$, to the common radius CI.

But since the lines CE and IH are parallel, the triangles BCE and BHI are similar, and give the proportion,

$$BE : BI :: CE : IH, \quad \text{or}$$

by placing for BE and BI, CE and IH, their values, we have,

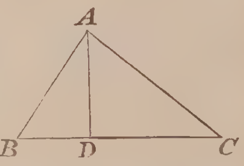
$$AB + AC : AB - AC :: \tan \tfrac{1}{2}(C + B) : \tan \tfrac{1}{2}(C - B).$$

THEOREM III.

In any plane triangle, if a line is drawn from the vertical angle perpendicular to the base, dividing it into two segments: then, the whole base, or sum of the segments, is to the sum of the other two sides, as the difference of those sides, to the difference of the segments.

65. Let BAC be a triangle, and AD perpendicular to the base BC; then will

$$BC : CA + AB :: CA - AB : CD - DB.$$



For, $\overline{AB}^2 = \overline{BD}^2 + \overline{AD}^2$ (Bk. IV., Prop. XI.); and $\overline{AC}^2 = \overline{DC}^2 + \overline{AD}^2$ by subtraction,

$$\overline{AC}^2 - \overline{AB}^2 = \overline{CD}^2 - \overline{BD}^2.$$

But, since the difference of the squares of two lines is equal to the rectangle contained by their sum and difference (Leg., Bk. IV., Prop. X.), we have,

$$\overline{AC}^2 - \overline{AB}^2 = (AC + AB) \, . \, (AC - AB)$$

and $$\overline{CD}^2 - \overline{DB}^2 = (CD + DB) \, . \, (CD - DB)$$

therefore, $(CD + DB) \, . \, (CD - DB) = (AC + AB) \, . \, (AC - AB)$

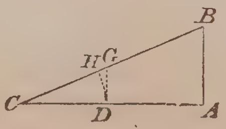
hence, $CD + DB : AC + AB :: AC - AB : CD - DB.$

THEOREM IV.

In any right-angled plane triangle, radius is to the tangent of either of the acute angles, as the side adjacent to the side opposite.

66. Let CAB be the proposed triangle, and denote the radius by R: then will

$$R : \tan C :: AC : AB.$$



For, with any radius as CD, describe the arc DH, and draw the tangent DG.

From the similar triangles CDG and CAB, we have,

$$CD : DG :: CA : AB; \quad \text{hence,}$$
$$R : \tan C :: CA : AB.$$

By describing an arc, with B as a centre, we could show in the same manner that,

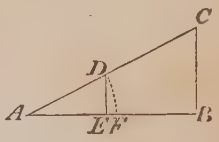
$$R : \tan B :: AB : AC.$$

THEOREM V.

In every right-angled plane triangle, radius is to the cosine of either of the acute angles, as the hypothenuse to the side adjacent.

67. Let ABC be a triangle, right-angled at B: then will

$$R : \cos A :: AC : AB.$$



For, from the point A as a centre, with any radius as AD, describe the arc DF, which will measure the angle A; and draw DE perpendicular to AB: then will AE be the cosine of A.

The triangles ADE and ACB, being similar, we have,

$$AD : AE :: AC : AB; \quad \text{that is,}$$
$$R : \cos A :: AC : AB.$$

SOLUTION OF TRIANGLES.

68. The relations between the sides and angles of plane triangles, demonstrated in these five theorems, are sufficient to solve all the cases of Plane Trigonometry. Of the six parts, which make up a plane triangle, three must be given, and at least one of these a side, before the others can be determined.

If the three angles only are given, it is plain, that an indefinite number of similar triangles may be constructed, the angles of which may be respectively equal to the angles that are given, and therefore, the sides could not be determined.

Assuming, with this restriction, any three parts of a triangle, as given, one of the four following cases, will always be presented.

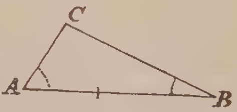
I. When two angles and a side are given.
II. When two sides and an opposite angle are given.
III. When two sides and the included angle are given.
IV. When the three sides are given.

CASE I.

69. **When two angles and a side are given.**

1. In a plane triangle, ABC, there are given the angle $A = 58° 07'$, the angle $B = 22° 37'$, and the side $AB = c = 408$ yards; to final C, a and b.*

GEOMETRICALLY.



Draw an indefinite straight line, AB, and from the scale of equal parts lay off AB equal to 408. Then at A, lay off an angle equal to 58° 07′, and at B an angle equal to 22° 37′, and draw the lines AC and BC: then will ABC be the triangle.

The angle C may be measured either with the protractor or the scale of chords, and will be equal to 99° 16′. The sides AC and BC mày be measured by referring them to the scale of equal parts. We shall find $AC = 158.9$ and $BC = 351$ yards.

TRIGONOMETRICALLY.

Add the given angles together, and subtract their sum from 180 degrees. The remaining parts of the triangle can then be found by Theorem I.

---

* The sides lying opposite the angles A, B and C, are denoted by a, b and c.

To the angle	$A = 58° \ 07'$
add the angle	$B = 22° \ 37'$
their sum	$= 80° \ 44'$
taken from	$180° \ 00'$
leaves C	$99° \ 16'$, of which,

as it exceeds 90°, we use the supplement 80° 44′.

To find BC = a.

From Theorem I., we have,

$$\sin C : \sin A :: c : a.$$

Applying logarithms, we have,

(a. c.) log sin C	(99° 16′)	0.005705
log sin A	(58° 07′)	9.928972
log c	(408)	2.610660
log a	351.024	2.545337

In like manner,

$$\sin C : \sin B :: c : b.$$

Applying logarithms, we have,

(a. c.) log sin C	(99° 16′)	0.005705
log sin B	(22° 37′)	9.584968
log c	(408)	2.610660
log b	158.976	2.201333

Ans. $C = 98° \ 16'$, $a = 351.024$, and $b = 158.976$.

NOTE.—The logarithm of the fourth term of a proportion is obtained by adding the logarithm of the second term to that of the third, and subtracting from their sum the logarithm of the first term. But to subtract the first term is the same as to add its arithmetical complement and reject 10 from the sum (Sec. I., Art. **17**): hence, the arithmetical complement of the first term added to the logarithms of the second and third terms, minus ten, will give the logarithm of the fourth term.

2. In a triangle ABC, there are given $A = 38° 25'$, $B = 57° 42'$, and $c = 400$: required the remaining parts.

Ans. $C = 83° 53'$, $a = 249.974$, $b = 340.04$.

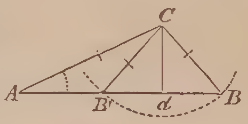
CASE II.

70. When two sides and an opposite angle are given.

In a plane triangle, ABC, there are given $AC = b = 216$, $CB = a = 117$, the angle $A = 22° 37'$, to find the other parts.

GEOMETRICALLY.

Draw an indefinite right line ABB': from any point, as A, draw AC, making $BAC = 22° 37'$, and make $AC = 216$. With C as a centre, and a radius equal to 117, the other given side, describe the arc $B'B$; draw CB and CB'; then will either of the triangles ACB or ACB', answer all the conditions of the question.



TRIGONOMETRICALLY.

From Theorem I., we have,

$$a : b :: \sin A : \sin B$$

By applying logarithms, we have,

(a. c.) log a (117) 7.931814
log b (216) 2.334454
log sin A (22°· 37′) 9.584968
log sin B, 45° 13′ 55″, or 134° 46′ 05″ . 9.851236

The ambiguity in this, and similar examples, arises in consequence of the first proportion being true for either of the angles ABC, or $AB'C$ which are supplements of each other, and therefore, have the same sine (Art. **56**). So long as the two triangles ACB and ACB' exist, the ambiguity will continue. But if the side CB, opposite the given angle, is greater than AC, the arc BB' will cut the line ABB', on the same side of the point A, in but one point, and then there will be only one triangle answering to the conditions.

If the side CB is equal to the perpendicular Cd, the arc BB' will be tangent to ABB', and in this case also, there will be but one triangle. When CB is less than the perpendicular Cd, the arc BB' will not intersect the base ABB', and in that case no triangle can be formed, or it will be impossible to fulfil the conditions of the problem.

In the example under consideration, there are two solutions, the first corresponding to $B' = 45° \, 13' \, 55''$, and the second to $ABC = 134° \, 46' \, 05''$.

First case.

A . . . . 22° 37′
B' . . . . 45° 13′ 55″
C . . . . . . 180° − 67° 50′ 55″ = 112° 09′ 05″.

Thus, in the triangle ACB',

$$\sin B' : \sin C :: b : c,$$

and applying logarithms,

(a. c.) log sin B' (45° 13′ 55″) 0.148764
log sin C (112° 09′ 05″) 9.966700
log b (216) 2.334454
log c 281.785 . . . . 2.449918

Second case.

A . . . . 22° 37′
B . . . . 134° 46′ 05″
C . . . . 180° − 157° 23′ 05″ = 22° 36′ 55″.

Thus, in the triangle ACB,

$$\sin B : \sin C : b : c,$$

and applying logarithms,

(a. c.) log sin B (134° 46′ 05″) . . .	0.148764
log sin C (22° 36′ 55″) . . .	9.584943
log b (216)	2.334454
log c 116.993	2.068161

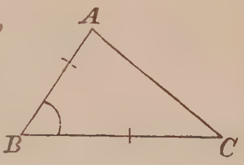
2. Given two sides of a triangle, 50 and 40 respectively, and the angle opposite the latter, equal to 32°: required the remaining parts of the triangle.

Ans. If the angle opposite the side 50 is acute, it is equal to 41° 28′ 59″; the third angle is then equal to 106° 31′ 01″, and the third side to 72.368. If the angle opposite the side 50 is obtuse, it is equal to 138° 31′ 01″, the third angle to 9° 28′ 59″, and the remaining side to 12.436.

CASE III.

71. When two sides and their included angle are given.

Let ABC be a triangle; AB and BC, the given sides, and B the given angle.



Since B is known, we can find the sum of the two other angles: for,

$$A + C = 180° - B, \quad \text{and}$$
$$\tfrac{1}{2}(A + C) = \tfrac{1}{2}(180° - B).$$

We next find half the difference of the angles A and C, by Theorem II., viz.,

$$BC + BA : BC - BA :: \tan \tfrac{1}{2}(A + C) : \tan \tfrac{1}{2}(A - C),$$

in which we consider BC greater than BA, and therefore A is greater than C; since the greater angle must be opposite the greater side.

Having found half the difference of A and C, by adding it to the half sum, $\frac{1}{2}(A + C)$, we obtain the greater angle, and by subtracting it from half the sum, we obtain the less. That is,

$$\tfrac{1}{2}(A + C) + \tfrac{1}{2}(A - C) = A, \text{ and}$$
$$\tfrac{1}{2}(A + C) - \tfrac{1}{2}(A - C) = C.$$

Having found the angles A and C, the third side AC may be found by the proportion,

$$\sin A : \sin B :: a : b.$$

EXAMPLES.

1. In the triangle ABC, let $BC = 540$, $AB = 450$, and the included angle $B = 80°$: required the remaining parts.

GEOMETRICALLY.

Draw an indefinite right line BC, and from any point, as B, lay off a distance $BC = 540$. At B make the angle $CBA = 80°$: draw BA, and make the distance $BA = 450$; draw AC; then will ABC be the required triangle.

TRIGONOMETRICALLY.

$BC + BA = 540 + 450 = 990$; and $BC - BA = 540 - 450 = 90$.

$A + C = 180° - B = 180° - 80° = 100°$, and therefore,

$$\tfrac{1}{2}(A + C) = \tfrac{1}{2}(100°) = 50°.$$

To find $\frac{1}{2}(A - C)$.

By Theorem II., we have,

$$BC + BA : BC - BA :: \tan \tfrac{1}{2}(A + C) : \tan \tfrac{1}{2}(A - C).$$

Applying logarithms, we have,

(a. c.) log $(BC + BA)$ (990) 7.004365
log $(BC - BA)$ (90) 1.954243
log tan $\frac{1}{2}(A + C)$ 50° . . . 10.076187
log tan $\frac{1}{2}(A - C)$ 6° 11′ . . 9.034795

Hence, $50° + 6° \ 11' = 56° \ 11' = A$; and $50° - 6° \ 11' = 43° \ 49' = C$.

To find the third side AC.

$$\sin C : \sin B :: c : b.$$

Applying logarithms, we have,

(a. c.) log sin C (43° 49')	0.159672
log sin B (80°)	9.993351
log c (450)	2.653213
log b 640.082	2.806236

2. Given two sides of a plane triangle, 1686 and 960, and their included angle 128° 04′: required the other parts.

Ans. Angles, 33° 34′ 39″; 18° 21′ 21″; side 2400.

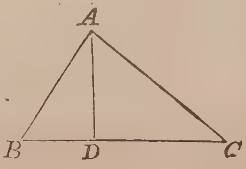
CASE IV.

72. Having given the three sides of a plane triangle to find the angles.

Let fall a perpendicular from the angle opposite the greater side, dividing the given triangle into two right-angled triangles: then find the difference of the segments of the base by Theorem III. Half this difference being added to half the base, gives the greater segment; and, being subtracted from half the base, gives the less segment. Then, since the greater segment belongs to the right-angled triangle having the greater hypothenuse, we have two sides and the right angle of each of two right-angled triangles, to find the acute angles.

EXAMPLES.

1. The sides of a plane triangle being given; viz., $BC = 40$, $AC = 34$, and $AB = 25$: required the angles.



GEOMETRICALLY.

With the three given lines as sides, construct a triangle as in Prob. IX. Then measure the angles of the triangle either with the protractor or scale of chords.

TRIGONOMETRICALLY.

$$BC : AC + AB :: AC - AB : CD - BD.$$

That is, $40 : 59 :: 9 : \dfrac{59 \times 9}{40} = 13.275.$

Then, $\dfrac{40 + 13.275}{2} = 26.6375 = CD,$

And, $\dfrac{40 - 13.275}{2} = 13.3625 = BD.$

In the triangle DAC, to find the angle DAC.

$$AC : DC :: \sin D : \sin DAC.$$

Applying logarithms, we have,

(a. c.) log AC (34)	8.468521
log DC (26.6375)	1.425493
log sin D (90°)	10.000000
log sin DAC 51° 34′ 40″ . .	9.894014

In the triangle BAD, to find the angle BAD.

$$AB : BD :: \sin D : \sin BAD.$$

Applying logarithms, we have,

(a. c.) log AB (25)	8.602060
log BD (13.3625)	1.125887
log sin D (90°)	10.000000
log sin BAD 32° 18′ 35″ . . .	9.727947

Hence, $90° - DAC = 90° - 51° \, 34' \, 40'' = 38° \, 25' \, 20'' = C$,

and, $90° - BAD = 90° - 32° \, 18' \, 35'' = 57° \, 41' \, 25'' = B$,

and, $BAD + DAC = 51° \, 34' \, 40'' + 32° \, 18' \, 35'' =$

$$= 83° \, 53' \, 15'' = A.$$

2. In a triangle, of which the sides are 4, 5, and 6, what are the angles?

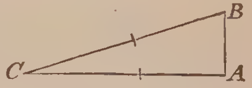
Ans. 41° 24′ 35″; 55° 46′ 16″; and 82° 49′ 09″.

SOLUTION OF RIGHT-ANGLED TRIANGLES.

73. The unknown parts of a right-angled triangle may be found by either of the four last cases; or, if two of the sides are given, by means of the property that the square of the hypothenuse is equal to the sum of the squares of the two other sides. Or, the parts may be found by Theorems IV. and V.

EXAMPLES.

1. In a right-angled triangle BAC, there are given the hypothenuse $BC = 250$, and the base $AC = 240$: required the other parts.



To find the angle B.

By Theorem I., we have,

$$a : b :: \sin A : \sin B.$$

Applying logarithms, we have,

(a. c.) log a (250)	7.602060
log b (240)	2.380211
log sin A (90°)	10.000000
log sin B 73° 44′ 23″	9.982271

But, $C = 90° - B = 90° - 73° \, 44' \, 23'' = 16° \, 15' \, 37''$.

To find side AB.

We have from Theorem IV.,

$$R \ : \ \tan C \ :: \ b \ : \ c.$$

Applying logarithms, we have,

(a. c.) log R	(90°)	0.000000
log tan C	(16° 15′ 37″)	9.464889
log b	(240)	2.380211
log c	70.0003	1.845100

2. In a right-angled triangle BAC, there are given,

$$AC = 384, \quad \text{and} \quad B = 53° \ 08′;$$

required the remaining parts.

Ans. $AB = 287.96$; $BC = 479.979$; $C = 36° \ 52′$.

BOOK II.

PLANE SURVEYING.

SECTION I.

MEASUREMENT OF LINES AND ANGLES.

1. Surveying, in its most extensive signification, comprises all the operations necessary for finding:

1st. The area or contents of any portion of the surface of the earth;

2d. The lengths and directions of the bounding lines; and,

3d. For making, on paper, an accurate delineation, both of the surface and boundaries; which delineation is called a *Map. or Plot.*

2. Plane Surveying is that branch in which the curvature of the earth is neglected; as it may be when the survey is limited to small portions of the surface.

3. Geodesic Surveying is when the curvature of the earth is taken into account, as it must be in all extensive surveys.

4. A Horizontal Plane, is a plane parallel to the water-level. If the plane passes through a point on the surface of the earth, it is tangent to the surface, and also perpendicular to the radius passing through the point of contact.

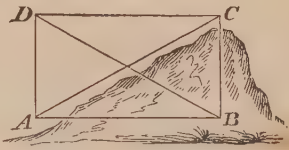
5. A Vertical Plane, is a plane perpendicular to a horizontal plane.

6. A Horizontal Line is a line parallel to the water-level, or parallel to a horizontal plane.

7. A Vertical Line, is a line perpendicular to a horizontal plane.

8. Oblique Lines, are those which are inclined to a horizontal plane.

Thus, *AB* and *DC* are horizontal lines; *BC* and *AD* are vertical lines; and *AC* and *BD* are oblique lines.



9. The Horizontal Distance between two points, is the horizontal line intercepted between the two vertical lines passing through those points. Thus, *DC* or *AB*, is the horizontal distance between the two points *A* and *C*, or between the points *B* and *D*.

10. A Horizontal Angle, is one, whose sides are horizontal: its plane is also horizontal. A horizontal angle is always equal to *the angle included between two vertical planes passing through the angular point and the two objects which subtend the angle.*

11. A Vertical Angle, is one, the plane of whose sides is vertical.

12. An Angle of Elevation, is a vertical angle having one of its sides horizontal, and the inclined side above the horizontal side. Thus, in the last figure, *BAC* is the angle of elevation from *A* to *C*.

13. An Angle of Depression, is a vertical angle having one of its sides horizontal, and the inclined side under the

horizontal side. Thus, *DCA* is the angle of depression from *C* to *A*.

14. AN OBLIQUE ANGLE, is one, the plane of whose sides is oblique to a horizontal plane.

15. All lines, which can be the object of measurement, must belong to one of the classes above named, viz.:

1st. Horizontal lines; 2d. Vertical lines; 3d. Oblique lines.

16. All angles may also be divided into three classes, viz.:

1st. Horizontal angles; whose sides are horizontal.

2d. Vertical angles; which include angles of elevation and angles of depression; and,

3d. Oblique angles, or those included by oblique lines.

MEASUREMENT OF LINES AND ANGLES.

17. It has been shown (Bk. I., Art. **45**), that at least one side and two of the other parts of a plane triangle must be given, or known, before the remaining parts can be found, by calculation.

When, therefore, distances are to be found, by trigonometrical calculations, two preliminary steps are necessary:

1st. To measure certain lines on the ground; and,

2d. To measure the necessary angles.

MEASUREMENT OF DISTANCES.

18. Any tape, rod, or chain, divided into equal parts, may be used as a measure; and this is called the *unit* of measure. The unit of measure may be a foot, a yard, a rod, or any other ascertained distance.

The measure in general use, is a chain of four rods or sixty-six feet in length; it is called Gunter's chain, from the name of the inventor. This chain is composed of 100 links.

Every tenth link, from either end, is marked by a small attached brass plate, which is notched, to designate its number from the end. The division of the chain, into 100 equal parts, is very convenient, since the divisions, or links, are decimals of the whole chain, and in the calculations are treated as such.

TABLE.

1 chain = 4 rods = 66 feet = 792 inches = 100 links.
1 link is equal to 7.92 inches.
80 chains = 320 rods = 1 mile.
40 chains = $\frac{1}{2}$ mile.
20 chains = $\frac{1}{4}$ mile.

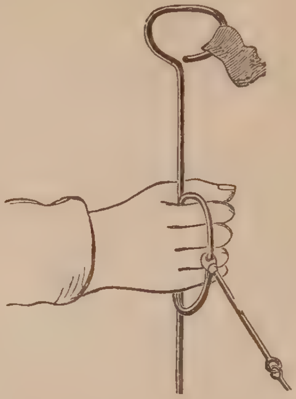
19. Besides the chain, there are needed for measuring, ten marking-pins, which should be of iron, each about ten inches in length and an eighth of an inch in thickness. These pins should be strung upon an iron ring, and this ring should be attached to a belt, to be passed over the right shoulder, suspending the pins at the left side.

To measure a horizontal line.

20. The point where the measurement is to begin is usually located by a staff or stake temporarily placed for the purpose; or by some one of the many permanent marks by which the angles in a boundary are fixed.

The other extremity of the line must be provided with a staff or flag which can be easily seen.

The fore-chainman, with the pins, and one handle of the chain in his right, starts off on the line, drawing out the chain to its full length. Both chainmen now examine it carefully, to see if there are any "kinks" at the junction of the links. Having adjusted the chain for use, the fore-chainman resumes his place, to be directed by the hind-chainman, so that the measurement shall be made exactly along the established line. To facilitate this, and to insure the correct alignment of the pin, at its proper distance, the chain and one pin should be held firmly in the right hand, as represented in the figure. While the pin is being aligned, it should be held by the fore-chainman as far from the body as possible, so that the view of the flag be left unobstructed. To accomplish this, and at the same time draw the chain to the proper degree of tension, the right arm should be braced against the inside of the right knee.



The hind-chainman directs, by the simple orders "right" or "left," according as the pin, held as described, is to be carried to the right or left to bring it into line with the flag. When the pin is truly in line, the chain at the same time being drawn straight, the order "down" is given, when the fore-chainman bringing his left hand to bear on the top of the pin, forces it vertically into the ground, and resumes his course to the length of another chain.

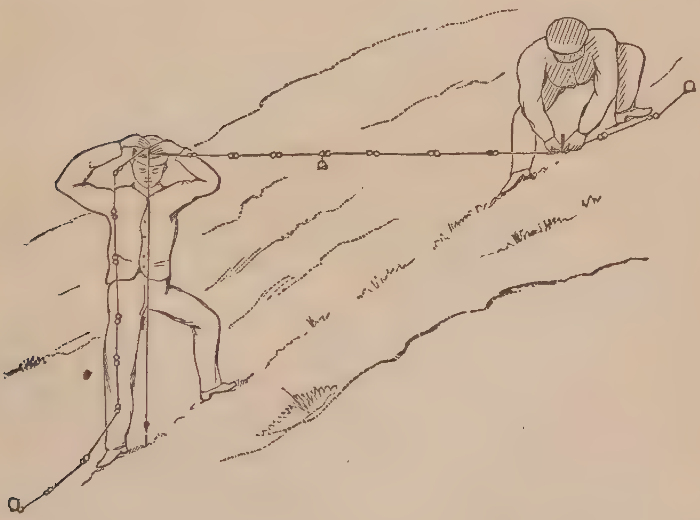
After one or two chains have been measured, on any line, the fore-chainman can, by glancing back to the station just left, place the pin nearly in the right position: the exact aligning should be left, however, to the hind-chainman.

"DOWN."

When the distance is more than ten chains, the pins, when exhausted, should be returned to the fore-chainman—the distance noted—and the chaining recommenced at the place of the tenth pin.

All distances should be measured horizontally: Hence, when the ground slopes, one end of the chain must be elevated. Each chainman should be provided with a small plumb-line, so that the elevated end of the chain may be held directly over the proper point.

When the raised end of the chain is only two, or even three feet above the ground, it will suffice, in many cases, to use a marking-pin, held lightly by the point, between the thumb and finger, instead of a plumb-line. When the chaining is on a steep inclination, other precautions should be observed.



Suppose the chaining to be *up hill.* The fore-chainman *draws the chain out to its full length,* as in any other case, and then returns to within such a distance of the hind-chainman, that when the chain is drawn out to that length horizontally, it shall not be too high to be held conveniently.

The hind-chainman holds his end of the chain carefully over the point or station, by means of the plumb-line, while he directs the fore-chainman in the usual manner.

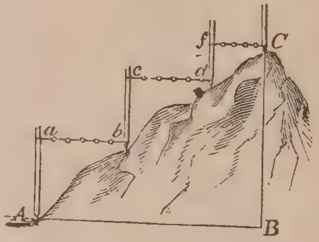
The point fixed in this manner, by the fore-chainman, must not be marked by a marking-pin, but by a small peg or nail. At the order, "Down," the fore-chainman does not go forward in the usual manner, but waits until the hind-chainman comes up and takes the chain by the precise point held, the moment before, to the ground.

This point is now held above the peg by the hind-chainman, who uses the plumb, as before, and aligns the fore-chainman, who has taken hold of the chain a few links farther on, and is holding it to the ground. These short distances are not recorded.

In chaining down-hill, the method is essentially the same. The fore-chainman uses the plumb, and determines by it where the peg is to be placed.

At the end of a course, the part of a chain is measured by drawing the chain *only to the flag*, where it is held by the fore-chainman, until the hind-chainman comes forward to the last pin, and counts the links.

In measuring up the hill from A to C, or down the hill from C to A, we measure the horizontal distances $a\ b$, $c\ d$, and $f\ C$, and their sum is the *horizontal* distance between A and C.



Two staves are often used with the chain, in the measurement of lines. Each of these should be about six feet in length, and have a spike in the lower end to aid in holding it firmly, and a horizontal strip of iron to prevent the chain from slipping off: each staff is to be passed through the ring, at the end of the chain.

STANDARD.

21. As the length of the chain may vary, from heat or cold, or become changed from other causes, it should be compared from time to time, with a *standard*, kept for the purpose.

To facilitate this comparison, let two stakes be driven in the ground, distant from each other *one chain*, and let nails be driven in the heads of the stakes to mark the exact length of the standard.

Marks made upon the coping of a wall will answer the same purpose. If it is found that any line has been measured with a chain, either too short or too long, the measured distance may be corrected by the following proportion:

As the length of the standard
: the length of the chain
:: the measured distance
: the true distance.

For the correction of areas we have this proportion:

As the square of the length of the standard
: the square of the length of the chain,
:: the area found
: the true area.

MEASUREMENT OF ANGLES.

22. We come next to the measurement of angles, and for this purpose, several instruments are used. The one, however, which affords the most accurate results, and which indeed can alone be relied on for nice or extended operations, is called a Theodolite. This instrument, only, will be described at present; others will be subsequently explained.

THE THEODOLITE.

23. Pl. 1.—The theodolite is an instrument used to measure horizontal and vertical angles. It is usually placed on a tripod *ABC*, which enters, by means of a screw, the lower horizontal plate *DE*, and becomes firmly attached to the body of the instrument. Through the horizontal plate *DE*, four small hollow cylinders are inserted, which receive four screws with milled heads, that work against a second horizontal plate, *FG*. The upper side of the plate *DE* terminates in a curved surface, which encloses a ball, that is nearly a semi-sphere, with the plane of its base horizontal. This ball, which is hollow, is firmly connected with the smaller base of a hollow conic frustum, that passes through the curved part of the plate *DE*, and screws firmly into the curved part of the second horizontal plate *FG*.

A hollow conic spindle passes through the middle of the ball, and the hollow frustum with which it is connected. To this spindle, a third horizontal and circular plate *HI*, called *the limb of the instrument*, is permanently attached. Within this spindle, and concentric with it, there is a second spindle, called the inner, or solid spindle. To this latter, is united a thin circular plate, called the *vernier plate*, which rests on the limb of the instrument, and supports the upper frame-work. The two spindles terminate at the base of the spherical ball, where a small screw enters the inner one, and presses a washer against the other, and the base of the ball. On the upper surface of the plate *FG*, rests a clamp which goes round the outer spindle, and which, being compressed by the clamp-screw *K*, is made fast to it. This clamp is thus connected with the plate *FG*. A small cylinder *a*, is fastened to the plate *FG*: through this cylinder a thumb-screw *L* passes, and works into a small cylinder *b*, connected with the clamp. The cylinders *b* and *a*, admit of a motion round their axes, so that the screw *L* may work through them freely.

Directly above the clamp, is the lower telescope *MN*. This telescope is connected with a hollow cylinder, which is worked freely round the outer spindle, by the thumb-screw *P*, having a pinion working into a concealed cog-wheel, that is permanently fastened to the limb of the instrument. By means of a clamp-screw *Q*, the telescope is made fast to the limb, when it will have a common motion with the limb and outer spindle.

The circular edge of the limb is chamfered, and is generally made of silver, and on this circle the graduation for horizontal angles is made. In the instrument described, the circle is divided into degrees and half-degrees; the degrees are numbered from 0 to 360.

On the circular edge of the vernier plate, is a small plate of silver, called a *vernier;* this plate is divided into 30 equal parts, and numbered from the line marked 0 to the left. Two levels, at right angles to each other, are attached to the vernier plate by small adjusting screws; one of the levels is seen in the figure.

The vernier plate turns freely around with the inner spindle. It is made fast to the limb of the instrument by the clamp-screw *S;* after which the smaller motions are made by the tangent-screw *T*. There is a compass on the vernier plate, that is concentric with it, the uses of which will be explained under the head, Compass.

The frame-work which supports the horizontal axis of the vertical semicircle *UV* and the upper telescope, with its attached level, rests on the vernier plate, to which it is made fast by three adjusting screws, placed at the angular points of an equilateral triangle. The vertical semicircle *UV*, is called the *vertical limb;* its motions are governed by the thumb-screw *Z*, which has a pinion that works with the teeth of the vertical limb. On the face of the vertical limb, opposite the thumb-screw *Z*, the limb is divided into degrees and half-degrees: the degrees are numbered both ways from the line marked 0. There is a small plate resting against the graduated face of the vertical limb, called the vernier; it is divided into 30 equal parts, and the middle line is designated by 0.

On the other face of the vertical limb, are two ranges of divisions, commencing at the 0 point, and extending each way 45°. The one shows the vertical distance of any object to which the upper telescope may be directed, above or below the place of the instrument, in 100th parts of the horizontal distance: the other, the difference between the hypothenusal and base lines—the hypothenuse being supposed to be divided into one hundred equal parts: therefore, by mere inspection, we can ascertain the number of links, which must be subtracted from every chain of an oblique line, to reduce it to a true horizontal distance.

The supports of the upper telescope are called the wyes, and designated *Y's*. Two loops, turning on hinges, pass over the telescope, and are made fast by the pins *c* and *d;* these loops confine the telescope in the *Y's*. By withdrawing the pins, and turning the loops on their hinges, the telescope may be removed for the purpose of being reversed in position; and in both situations, the telescope can be revolved in the *Y's* about its axis.

In the telescopes attached to the theodolite, are two principal lenses, one at each end. The one at the end where the eye is placed, is called the *eye-glass*, the other the *object-glass*.

In order that the axis of the telescope may be directed to an object with precision, two spider's lines, or small hairs, are fixed at right angles to each other, and placed within the barrel of the telescope, and at the focus of the eye-glass. The vertical hair is moved by two small horizontal screws, one of which, *f*, is seen in the figure; and the horizontal hair, by two vertical screws, *g* and *h*.

ADJUSTMENTS OF THE THEODOLITE.

24. Before using the instrument, it must be *adjusted;* that is, the parts must be brought to their proper relative positions. There are *four* principal *adjustments.*

FIRST ADJUSTMENT.—*To fix the intersection of the spider's lines in the axis of the telescope, which is called the line of collimation.*

Having screwed the tripod to the instrument, extend the legs, and place them firmly. Then loosen the clamp-screw *S*, of the vernier plate, and direct the telescope to a small, well-defined, and distant object. By means of a small pin *i*, on the under side of the telescope, slide the eye-glass till the spider's lines are distinctly seen; then with the thumb-screw *X*, which forces out and draws in the object-glass, adjust this glass to its proper focus, when the object, as well as the spider's lines, will be distinctly seen: after which, by the tangent-screw *T* and the thumb-screw *Z*, bring the intersection of the spider's lines exactly upon a well-defined point of the object.

Having done this, revolve the telescope in the *Y's* half round, when the attached level *mn* will come to the upper side. See if, in this position, the horizontal hair appears above or below the point; and in either case, loosen one, and tighten the other, of the two screws that work the horizontal hair, till the horizontal hair has been carried over half the space between its last position and the observed point. Carry the telescope back to its place; direct again the intersection of the spider's lines to the point, and repeat the operation till the horizontal hair neither ascends nor descends, while the telescope is revolved. A similar process will arrange the vertical hair, and the line of collimation is then adjusted.

SECOND ADJUSTMENT.—*To make the axis of the attached level of the upper telescope, parallel to the line of collimation.*

Turn the vernier plate, till the telescope comes directly over two of the levelling screws, between the plates *DE* and *FG*. Turn these screws contrary ways, keeping them firm against the plate *FG*, till the bubble of the level *mn* stands at the middle of the tube. Then, open the loops, and reverse the telescope. If the bubble still stands in the middle of the tube, the axis of the tube is horizontal; but if not, it is inclined, the bubble being at the elevated end. In that case, by means of the small vertical screws *m* and *n*, at the ends of the level, raise the depressed end, or depress the elevated one, half the inclination; and then, with the levelling screws, bring the level into a horizontal position. Reverse the telescope in the *Y's*, and make the same correction again; and so on, until the bubble stands in the middle of the tube, in both positions of the telescope: the axis of the level is then horizontal. Let the telescope be now revolved in the *Y's*. If the bubble continue in the middle of the tube, the axis of the level is not only horizontal, but also parallel to the line of collimation. If, however, the bubble recede from its centre, the axis of the level is inclined to the line of collimation, and must be made parallel to it by means of two small antagonistic screws (one of which is seen at *p*), which work horizontally. By loosening one of them, and tightening the other, the level is soon brought parallel to the line of collimation, and then, if the telescope be revolved in the *Y's*, the bubble will continue in the middle of the tube.

It is difficult to make the first part of this adjustment, while the axis of the level is considerably inclined to the line of collimation; for, if the level were truly horizontal in one position of the telescope, when the telescope is reversed, the bubble would not stand in the middle of the tube, except in one position of the level. This suggests the necessity of making the first part of the adjustment with tolerable accuracy; then, having made the second with care, let the first be re-examined, and proceed thus till the adjustment is completed.

THIRD ADJUSTMENT.—*To make the axes of the levels, on the limb, perpendicular to the axis of the instrument.*

This adjustment is effected, partly by the levelling screws, and partly by the thumb-screw *Z*. Turn the vernier plate, until the upper telescope comes directly over two of the levelling screws, then turn the screws contrary ways, till the upper telescope is horizontal; after which, turn the vernier plate 180°, and if the bubble of the level remains in the middle of the tube, one line of the limb is horizontal. But if the bubble recedes from the centre of the level, raise the lower, or depress the upper end, one-half, by the levelling screws, the other by the thumb-screw *Z*, till it is brought into a horizontal position. Turn the vernier plate again 180°, and if the level be not then horizontal, make it so, by dividing the error as before, and repeat the operation until the line of the limb is truly horizontal. Then turn the vernier plate 90°, and level as before. The limb ought now to be truly horizontal; but, lest the first horizontal line may have been changed, in obtaining the second, it is well to bring the telescope and level, two or three times over the levelling screws, until an entire revolution can be made without displacing the bubble from the middle of the tube. As this can only take place when the level revolves around a vertical line, it follows that the limb will then be horizontal, and the axis of the instrument vertical. Then, by means of the small screws at the ends of the levels, bring the bubbles to the centres, and the axes of the levels will be perpendicular to the axis of the instrument.

FOURTH ADJUSTMENT.—*To make the axis of the vertical limb perpendicular to the axis of the instrument.*

Bring the intersection of the spider's lines of the upper telescope upon a plumb-line, or any well-defined vertical object, and move the telescope with the thumb-screw *Z:* if the intersection of the spider's lines continues on the vertical line, the axis is horizontal.

Or, the adjustment may be effected thus: Direct the intersection of the spider's lines to a well-defined point that is considerably elevated: then turn the vertical limb, until the axis of the telescope rests on some other well-defined point, upon or near the ground: reverse the telescope, and turn the vernier plate 180°; then, if in elevating and depressing the telescope, the line of collimation passes through the two points before noted, the axis is horizontal. If it be found, by either of the above methods, that the axis is not horizontal, it must be made so by the screws which fasten the frame-work to the vernier plate.

There are two important lines of the theodolite, the positions of which are determined with great care by the maker, and fixed permanently. First, the axis of the instrument is placed exactly at right angles with the limb and vernier plate; and unless it have this position, the vernier plate will not revolve at right angles to the axis, as explained in the third adjustment.

Secondly, the line of collimation of the upper telescope is fixed at right angles to the horizontal axis of the vertical limb. We can ascertain whether these last lines are truly at right angles, by directing the intersection of the spider's lines to a well-defined point; then removing the caps which confine the horizontal axis in its supports, and reversing the axis: if the intersection of the spider's lines can be made to cover exactly the same point, without moving the vernier plate, the line of collimation is at right angles to the axis.

If the theodolite be so constructed that either of the *Y's* admits of being moved laterally, so as to vary the angle between the horizontal axis and the line of collimation, these lines may be adjusted at right angles to each other, if they have not been so placed by the maker.

The lower telescope, being used merely as a guard, requires no adjustment, although it is better to make the axis, about which its vertical motions are performed, horizontal, or perpendicular to the axis of the instrument; and this is easily effected by means of the two small screws *k* and *l*, which work into the slide *A′*, that is connected with the horizontal axis.

Having explained the methods of properly adjusting the theodolite, we will now explain the particular uses of its several parts in the measurement of angles.

VERNIERS.

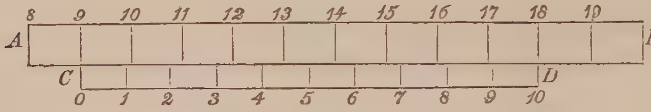
25. Before explaining the vernier, as applied to the theodolite, we shall discuss the general theory of verniers.

A VERNIER is a contrivance for measuring smaller arcs than those into which the limb of an instrument is divided.

It is a graduated scale, so arranged, as to cover an exact number of equal spaces on the primary scale or *limb*, to which it is applied. It is divided into a number of equal parts, greater by one than the number of equal spaces which it covers on the limb.

The vernier may be applied to any limb or scale of equal parts. The modes of its application are extremely various;

the principle, however, is the same in all, and may be illustrated by a simple diagram.



Let AB be any *limb* or scale of equal parts, one of which let us suppose equal to b. Let CD be a *vernier*, equal in length, say to nine of these parts, and itself divided into ten equal spaces, each one of which is then equal to nine-tenths of b. The *difference* between a space on the limb and a space on the vernier, is therefore equal to one-tenth of b, or $\frac{1}{10}b$. This is the least space that can be measured by means of the vernier, and is called the *least count;* hence,

The least count of a vernier is equal to one of the equal divisions of the limb divided by the number of spaces on the vernier.

READINGS.

26. The true reading of an instrument, for any position of the vernier, expresses the distance from the point where the graduation on the limb begins, marked 0, to the 0 point of the vernier. In the diagram, that distance is expressed by nine units of the limb, or 9.

If, now, the vernier be moved till the division 1 coincides with the division 10 of the limb, the 0 point will have advanced along the limb a distance equal to $\frac{1}{10}b$, and the reading will become $9 + \frac{1}{10}b$. If we again move the vernier till the division 2 coincides with the division 11 of the limb, the 0 point will have advanced an additional distance, equal to $\frac{1}{10}b$, and the reading becomes $9 + \frac{2}{10}b$; when 3 coincides with division 12, the reading will become $9 + \frac{3}{10}b$, and so on, till finally, when the point 10 coincides with 19 of the limb, the distance 9 will have been increased by $\frac{10}{10}b$, and will become 10, as it should, since, in that case, the 0 point will have been moved a whole space, and will coincide with the division 10 of the limb. Hence, the following rule for reading an instrument which has a vernier:

Read the limb in the direction of the graduation up to the division line next preceding the 0 point of the vernier; this is called the reading on the limb. Look along the vernier till a line is found to coincide with a line of the limb: multiply the number of this first line by the least count of the vernier: this is the reading on the vernier: the sum of these two readings is the reading of the instrument.

In the theodolite described, the limb is divided into half-degrees, and 30 spaces on the vernier cover 29 spaces on the limb. Hence, the least count of this instrument is $\frac{1}{30}$ of a half-degree, or 1′. Fig. 2, Plate 1, exhibits the vernier of the horizontal limb, and Fig. 3, the vernier of the vertical limb.

TO MEASURE A HORIZONTAL ANGLE WITH THE THEODOLITE.

27. Place the axis of the instrument directly over the point at which the angle is to be measured. This is effected by means of a plumb, suspended from the centre of the plate which forms the upper end of the tripod.

Having made the limb truly level, place the 0 of the vernier at 0, or 360° of the limb, and fasten the clamp-screw S of the vernier plate. Then, facing in the direction between the lines which subtend the angle to be measured, turn the limb with the outer spindle, until the telescope points to the object on the left, very nearly. Clamp the limb with the clamp-screw K, and by means of the tangent-screws L and Z, bring the intersection of the spider's lines to coincide exactly with the object.

Having loosened the clamp-screw Q, of the lower telescope MN, direct it with the thumb-screw P to the same object at which the upper telescope is directed; then tighten the clamp-screw Q. This being done, loosen the clamp-screw S of the vernier plate, and direct the telescope to the other object: the arc passed over by the 0 point of the vernier, is the measure of the angle sought.

The lower telescope having been made fast to the limb, will indicate any change of the position of the limb, should any have taken place; and, as the accuracy of the measurements depends on the fixedness of the limb, the lower telescope ought to be often examined, and, if its position has been altered, the limb must be brought back to its place by the tangent-screw L.

NOTE.—It is not necessary to place the 0 point of the vernier at the 0 point of the limb, previously to commencing the measurement of the angle, but convenient merely; for, whatever be the position of this point on the limb, it is evident that the arc which it passes over is the true measure of the horizontal angle. If, therefore, its place be carefully noted for the first direction, and also for the second, the difference of these two readings will be the true angle, unless the 0 point of the vernier shall have passed the 0 point of the limb, in which case the greater reading must be subtracted from 360°, and the remainder added to the less.

MEASUREMENT OF VERTICAL ANGLES.

28. We shall first explain the method of determining the *index error*. Having levelled the horizontal limb, direct the telescope to some distinctly marked object, as the top of a chimney, and read the instrument. Reverse the telescope in the Y's, and turn the vernier plate 180°, and having directed the telescope to the same object, again, read the instrument. If the two readings are the same, the limb is adjusted; that is, the 0 of the limb coincides with the 0 of its vernier, when the axis of the telescope is parallel to the horizontal limb.

When the reading, found with the eye end of the telescope nearest the vernier, is greater than that obtained in the reversed position, the true elevation of the object, which is equal to a mean of the readings, may be obtained by *subtracting* half the difference from the first reading. If the first reading is less than the second, the half difference must be added to the first. Hence,

To find the index error, take the reading of the limb when the telescope is directed to a fixed object, first with the eye end of the telescope nearest the vernier, and then with the telescope and vernier plate both reversed. Take half the difference of these readings, and affect it with a minus sign if the first is the greater, or a plus sign if the second is the greater; this is equal to the index error.

Let the operation be repeated several times, using different objects, and a mean of the errors will be more correct than the result of a single observation.

29. Having determined the index error, let the axis of the telescope be directed to any point either above or below the plane of the limb, and read the arc indicated by the 0 of the vernier. To the arc so read, apply the proper correction, if any, and the result will be the true angle of elevation or depression.

The angle of elevation may be more correctly found by taking the elevation of the object, and repeating the observation with the telescope and vernier plate reversed, and then taking a mean of the readings for the angle required.

MEASUREMENTS WITH THE TAPE OR CHAIN ONLY.

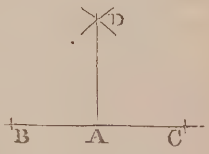
30. It often happens that instruments for the measurement of angles cannot be easily obtained; we must then rely entirely on the tape or chain.

We now propose to explain the best methods of determining distances, without the aid of instruments for the measurement of horizontal or vertical angles.

I. To trace, on the ground, the direction of a right line, that shall be perpendicular at a given point, to a given right line.

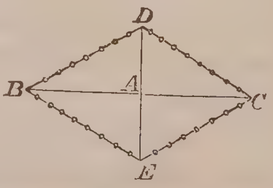
FIRST METHOD.

31. Let BC be the given right line, and A the given point. Measure from A, on the line BC, two equal distances AB, AC, one on each side of the point A. Take a portion of the chain or tape, greater than AB, and place one extremity at B, and with the other, trace the arc of a circle on the ground. Then remove the end which was at B to C, and trace a second arc intersecting the former at D. The straight line, drawn through D and A, will be perpendicular to BC at A.

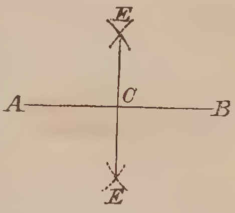


SECOND METHOD.

32. Having made $AB = AC$, take any portion of the tape or chain, considerably greater than the distance between B and C. Mark the middle point of it, and fasten its two extremities, the one at B and the other at C. Then, taking the chain by the middle point, stretch it tightly on either side of BC, and place a staff at D or E: DAE will be the perpendicular required.



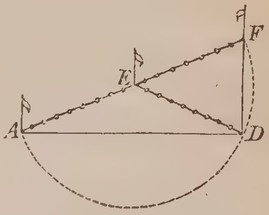
THIRD METHOD.



33. Let *AB* be the given line, and *C* the point at which the perpendicular is to be drawn. From the point *C*, measure a distance *CA* equal to 8. With *C* as a centre, and a radius equal to 6, describe an arc on either side of *AB*: then, with *A* as a centre, and a radius equal to 10, describe a second arc intersecting the one before described, at *E*: then draw the line *EC*, and it will be perpendicular to *AB* at *C*.

NOTE.—Any three lines, having the ratio of 6, 8, and 10, form a right-angled triangle, of which the side corresponding to 10 is the hypothenuse.

FOURTH METHOD.



34. Let *AD* be the given right line, and *D* the point at which the perpendicular is to be drawn. Take any distance, on the tape or chain, and place one extremity at *D*, and fasten the other at some point, as *E*, between the two lines which are to form the right angle. Place a staff at *E*. Then, having stationed a person at *D*, remove that extremity of the chain and carry it round until it ranges on the line *DA*, at *A*. Place a staff at *A*: then remove the end of the chain at *A*, and carry it round until it falls on the line *AE*, prolonged, at *F*. Then place a staff at *F*; *ADF* will be a right angle, being an angle in a semicircle.

NOTE.—There is a very simple instrument, used exclusively in laying off right angles on the ground, which is called the

Surveyor's Cross.

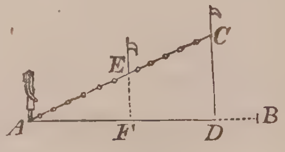
35. This instrument consists of two bars, *AB* and *CD*, Pl. 2, Fig. 1, permanently fixed at right angles to each other, and firmly attached at *E*, to a pointed staff, which serves as a support. Four sights are screwed firmly to the bars, by means of the screws *a*, *b*, *c*, and *d*.

As the only use of this instrument is to lay off right angles, it is of the first importance that the lines of sight be truly at right angles. To ascertain if they are so, let the bar *AB* be turned until its sights mark some distinct object; then look through the other sights, and place a staff on the line which they indicate: let the cross be then turned until the sights of the bar *AB* come to this last line: if the other sights are directed to the first object, the lines of sight are exactly at right angles.

The sights being at right angles, if one of them be turned in the direction of a given line, the other will mark the direction of a line perpendicular to it, at the point where the instrument is placed.

II. From a given point without a straight line, to let fall a perpendicular on the line.

36. Let *C* be the given point, and *AB* the given line.



From *C*, measure a line, as *CA*, to any point of the line *AB*. From *A*, measure on *AB* any distance as *AF*, and at *F* erect *FE* perpendicular to *AB*.

Having stationed a person at *A*, measure along the perpendicular *FE* until the forward staff is aligned on the line *AC*:

then measure the distance AE. Now, by similar triangles, we have,

$$AE : AF :: AC : AD,$$

in which all the terms are known except AD, which may, therefore, be found. The distance AD being laid off from A, the point D, at which the perpendicular CD meets AB, becomes known. If we wish the length of the perpendicular, we use the proportion,

$$AE : EF :: AC : CD,$$

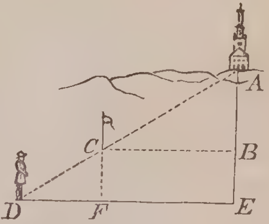
in which all the terms are known, excepting CD: therefore, CD is determined.

III. To determine the horizontal distance from a given point to an inaccessible object.

FIRST METHOD.

37. Let A be an inaccessible object, and E the point from which the distance is to be measured.

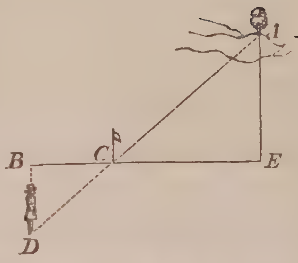
At E, lay off the right angle AED, and measure in the direction ED, any convenient distance to D, and place a staff at D. Then measure from E, directly towards the object A, a distance EB of any convenient length, and at B, lay off a line BC perpendicular to EA. Measure along the line BC, until a person at D shall range the forward staff on the line DA. Now, DF is known, being equal to the difference between the two measured lines DE and CB. Hence, by similar triangles,



$$DF : FC :: DE : EA,$$

in which proportion all the terms are known, except the fourth, which is therefore found.

SECOND METHOD.



38. At the point *E*, lay off *EB* perpendicular to the line *EA*, and measure along it any convenient distance, as *EB*.

At *B* lay off the right angle *EBD*, and measure any distance in the direction *BD*. Let a person at *D* align a staff on *DA*, while a second person at *B* aligns it on *BE*: the staff will thus be fixed at *C*. Then measure the distance *BC*.

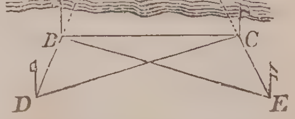
The two triangles *BCD* and *CAE* being similar, we have,

$$BC : BD :: CE : EA,$$

in which all the terms are known, except the fourth, which is, therefore, found.

THIRD METHOD.

39. Let *B* be the given point, and *A* the inaccessible object; it is required to find *BA*.



Measure any horizontal base-line, as *BC*. Then, having placed staves at *B* and *C*, measure any convenient distances *BD* and *CE*, such that the points *D*, *B*, and *A*, shall be in the same right line, as also, the points *E*, *C*, and *A*; then measure the diagonal lines *DC* and *EB*.

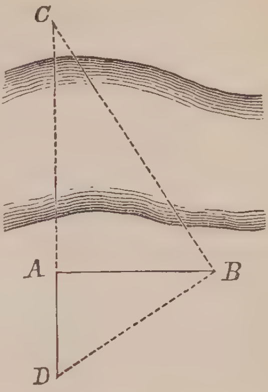
Now, in the triangle *BEC*, the three sides are known, therefore, the angle *ECB* can be found. In the triangle *CDB*, the three sides are also known, therefore the angle *CBD* can be determined. These angles being respectively subtracted from 180°, the two angles *ACB* and *ABC* become known; and hence, in the triangle *ABC*, we have two angles and the included side, to find the side *BA*.

FOURTH METHOD.

40. Let *AC* be the distance required. Lay off the right angle *CAB*, and measure *AB*, any convenient distance. At *B* lay off the right angle *CBD*, and fix the point *D*, carefully, in line with *AC*. Measure *AD*. Then,

$$AD : AB :: AB : AC \therefore AC = \frac{\overline{AB}^2}{AD.}$$

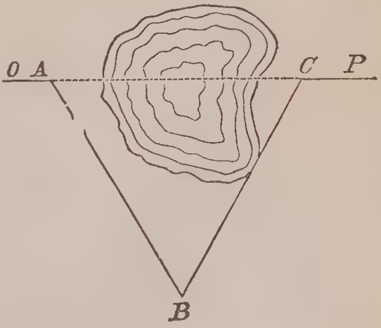
(Legendre, Bk. IV., Prop. 23.)



NOTE.—When such problems occur in practice, the distance *AC* is usually a portion of a longer line, so that the line *CAD* is well marked by stakes or pins, before *AB* is measured.

IV. To prolong a line beyond an obstacle.

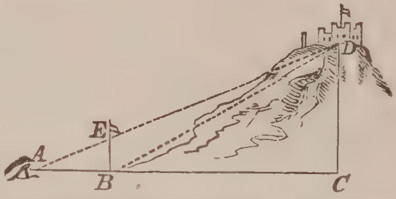
41. Let *OA* be the line to be prolonged. Lay off *OAB* $= 120°$, or $CAB = 60°$. Measure *AB*, of such length as to permit *BC* to be measured without meeting the obstruction. Make $ABC = 60°$, and measure *BC*, equal to *AB*. If *A* be not in sight from *C*, make the angle *BCP* equal to 120°, and resume the survey of the line. *AC* is equal to *AB* or *BC*.



NOTE.—This method may be employed in the absence of any angular instruments, by constructing an equilateral triangle with the chain. Holding together the end of the chain with the 90-link point, let two assistants draw out at the 30, and at the 60 point, until the three lines are straight.

V. To find the altitude of an object, when the distance to the vertical line passing through the top of it is known.

42. Let *CD* be the altitude required, and *AC* the known distance.



From *A*, measure on the line *AC*, any convenient distance *AB*, and place a staff vertically at *B*. Then placing the eye at *A*, sight to the object *D*, and let the point, at which the line *AD* cuts the staff *BE*, be marked. Measure the distance *BE* on the staff; then,

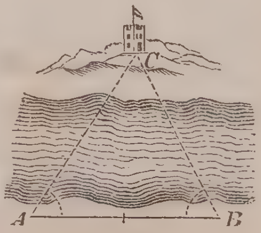
$$AB : BE :: AC : CD,$$

whence *CD* becomes known.

If the line *AC* cannot be measured, on account of intervening objects, it may be determined by calculation, as in the last problem, and then, having found the horizontal distance, the vertical line is readily determined, as before.

APPLICATIONS TO HEIGHTS AND DISTANCES.

I. To determine the horizontal distance to a point which is inaccessible by reason of an intervening river.



43. Let *C* be the point. Measure along the bank of the river a horizontal base-line *AB*, and select the stations *A* and *B*, in such a manner that each can be seen from the other, and the point *C* from both of them. Then measure the horizontal angles *CAB* and *CBA*, with an instrument adapted to that purpose.

Let us suppose that we have measured $AB = 600$ yards; $CAB = A = 57° 35''$, and $CBA = B = 64° 51'$.

Then, $$C = 180° - (A + B) = 57° 34'.$$

To find the distance BC.

$$\sin C : \sin A :: AB : BC.$$

Applying logarithms, we have,

(a. c.)	log sin C	(57° 34′)	0.073649
	log sin A	(57° 35′)	9.926431
	log AB	(600)	2.778151
	log BC	600.11	2.778231

To find the distance AC.

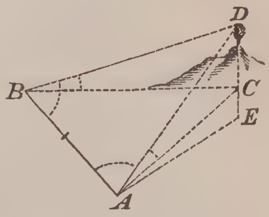
$$\sin C : \sin B :: AB : AC,$$

and applying logarithms, we have,

(a. c.)	log sin C	(57° 34′)	0.073649
	log sin B	(64° 51′)	9.956744
	log AB	(600)	2.778151
	log AC	643.94	2.808544

II. To determine the altitude of an inaccessible object above a given horizontal plane.

FIRST METHOD.



44. Suppose D to be an inaccessible object, and BC the horizontal plane from which the altitude is to be measured: then, if we suppose DC to be a vertical line, it will represent the required distance.

Measure any horizontal base-line, as BA; and at the extremities B and A, measure the horizontal angles CBA and CAB. Measure, also, the angle of elevation DBC.

Then, in the triangle CBA, there will be known, two angles and the side *AB;* the side *BC* can therefore be found by calculation. Having found *BC*, we shall have, in the right-angled triangle *DBC*, the base *BC* and the angle at the base, to find the perpendicular *DC*, which measures the altitude of the point *D*, above the horizontal plane *BC*.

Let us suppose that we have found, by measurement,

$$BA = 780 \text{ yards.}$$

The horizontal angle $CBA = B = 41° \; 24'$,
the horizontal angle $CAB = A = 96° \; 28'$,
and the angle of elevation $DBC = 10° \; 43'$.

To find, in the triangle BCA, the horizontal distance BC.

The angle $BCA = C = 180° - (A + B) = 42° \; 08'$.

Then, $\sin C \; : \; \sin A \; :: \; AB \; : \; BC;$

and applying logarithms, we have,

(a. c.)	log sin C	$(42° \; 08')$	0.173369
	log sin A	$(96° \; 28')$	9.997228
	log AB	(780)	2.892095
	log BC	1155.29 yards . . .	3.062692

In the right-angled triangle DCB, to find DC.

We have, from Theorem IV.,

$$R \; : \; \tan DBC \; :: \; BC \; : \; DC.$$

Applying logarithms, we have,

(a. c.)	log R	$(90°)$	0.000000
	log tan DBC	$(10° \; 43')$ . . .	9.277043
	log BC	(1155.29) . . .	3.062692
	log DC	218.64	2.339735

NOTE 1.—It might, at first, appear, that the solution which we have given, requires that the points *B* and *A* should be in

the same horizontal plane; but it is entirely independent of such a supposition.

For, the horizontal distance, represented by BA, is the same, whether the station A is on the same level with B, above it, or below it. The horizontal angles CAB and CBA are also the same, so long as the point C is in the vertical line DC. Therefore, if the horizontal line through A should cut the vertical line DC, at any point, as E, above or below C, AB would still be the horizontal distance between B and A, and AE, would be the horizontal distance between A and C.

If at A, we measure the angle of elevation at the point D, we shall know in the right-angled triangle DAE, the base AE, and the angle at the base; from which the perpendicular DE can be determined.

Let us suppose that we had measured the angle of elevation DAE, and found it equal to 20° 15′.

First: In the triangle BAC, to find AC, or its equal AE.

$$\sin C : \sin B :: AB : AC \text{ or } AE.$$

Applying logarithms, we have,

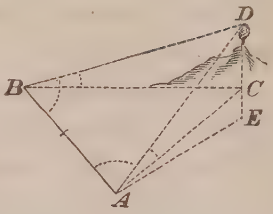
(a. c.)	log sin C	(42° 08′)	0.173369
	log sin B	(41° 24′)	9.820406
	log AB	(780)	2.892095
	log AE	768.9	2.885870

In the right-angled triangle DAE, to find DE.

We have, from Theorem IV.,

$$R : \tan A :: AE \,.\, DE : \quad \text{hence,}$$

(a. c.)	log R	(90°)	0.000000
	log tan A	(20° 15″)	9.566932
	log AE	(768.9)	2.885870
	log DE	283.66	2.452802



Now, since DC is less than DE, it follows that the station B is above the station A. That is,

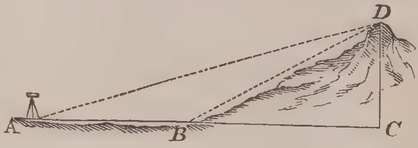
$$DE - DC = 283.66 - 218.64 = 65.02 = EC,$$

which expresses the vertical distance that the station B is above the station A.

NOTE 2.—It should be remembered, that the vertical distance which is obtained by the calculation, is estimated from a horizontal line passing through the eye, at the time of observation. Hence, the height of the instrument is to be added, in order to obtain the true result.

SECOND METHOD.

45. When the nature of the ground will admit of it, measure a base-line AB, in the direction of the object D. Then measure, with the instrument, the angles of elevation at A and B.



Then, since the outward angle DBC is equal to the sum of the angles A and ADB, it follows that, the angle ADB is equal to the difference of the angles of elevation at A and B. Hence, we can find all the parts of the triangle ADB. Having found DB, and knowing the angle DBC, we can find the altitude DC.

This method supposes that the stations A and B are on the same horizontal plane; and therefore it can only be used when the line AB is nearly horizontal.

Let us suppose that we have measured the base-line and the two angles of elevation, and found,

$AB = 975$ yards, $A = 15°\ 36'$, and $DBC = 27°\ 29'$; required the altitude DC.

First: $ADB = DBC - A = 27°\ 29' - 15°\ 36' = 11°\ 53'$.

In the triangle ADB, to find BD.

$$\sin D : \sin A :: AB : DB; \quad \text{hence,}$$

(a. c.) log sin D (11° 53′) 0.686302
log sin A (15° 36′) 9.429623
log AB (975) 2.989005
log BD 1273.3 . . . . . . 3.104930

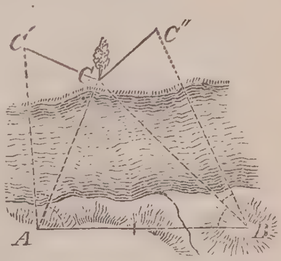
In the triangle DBC, to find DC.

We have, Theorem I.,

$$R : \sin B :: BD : DC; \quad \text{hence,}$$

(a. c.) log R (90°) 0.000000
log sin B (27° 29′) 9.664163
log C (1273.3) 3.104930
log DC 587.61 . . . . . . 2.769093

III. To determine the perpendicular distance of an object below a given horizontal plane.



46. Suppose C to be directly over the given object, and A the point through which the horizontal plane is supposed to pass.

Measure a horizontal base-line AB, and at the stations A and B conceive the two horizontal lines AC, BC, to be drawn. The oblique lines from A and B, to the object, are the hypothenuses of two right-angled triangles, of which AC, BC, are the bases. The perpendiculars of these triangles are the distances from the horizontal lines AC, BC, to the object. If we turn the triangles about their bases AC, BC, until they become horizontal, the object, in the first case, will fall at C', and in the second at C''.

Measure the horizontal angles CAB, CBA, and also the angles of depression $C'AC$, $C''BC$.

Suppose that we have measured, and found $AB = 672$ yards; $BAC = 72° \ 29'$; $ABC = 39° \ 20'$; angle of depression $C'AC = 27° \ 49'$, and $C''BC = 19° \ 10'$.

First: In the triangle ABC, the horizontal angle $ACB = 180° - (A + B) = 180° - 111° \ 49' = 68° \ 11'$.

To find the horizontal distance AC

$\sin C : \sin B :: AB : AC$; hence,

(a. c.)	log sin C (68° 11′)	0.032275
	log sin B (39° 20′)	9.801973
	log AB (672)	2.827369
	log AC 458.79	2.661617

To find the horizontal distance BC.

$\sin C : \sin A :: AB : BC$; whence,

(a. c.)	log sin C (68° 11′)	0.032275
	log sin A (72° 29′)	9.979380
	log AB (672)	2.827369
	log BC 690.28	2.839024

In the right-angled triangle CAC′, to find CC′.

We have, Theorem IV.,

$R : \tan A :: AC : CC'$; whence,

(a. c.)	log R (90°)	0.000000
	log tan A (27° 49′)	9.722315
	log AC 458.79	2.661617
	log CC' 242.06	2.383932

In the triangle CBC'', to find CC''.

We have, Theorem IV.,

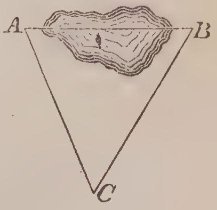
$$R : \tan B :: BC : CC''; \text{ whence,}$$

(a. c.)	$\log R$	$(90°)$	0.000000
	$\log \tan B$	$(19° \ 10')$	9.541061
	$\log BC$	(690.28)	2.839024
	$\log CC''$	239.93	2.380085

Hence, also, $CC' - CC'' = 242.06 - 239.93 = 2.13$ yards; which is the height of station A above station B.

PROBLEMS.

1. Wanting to know the distance between two inaccessible objects, which lie in a direct level line from the bottom of a tower 120 feet in height, the angles of depression are measured from the top of the tower, and are found to be, of the nearer 57°, and of the more remote 25° 30′: required the distance between the objects. *Ans.* 173.656 feet.



2. In order to find the distance between two trees, A and B, which could not be directly measured because of a pool which occupied the intermediate space, the distances of a third point C from each of them were measured, and also the included angle ACB: it was found that,

$$CB = 672 \text{ yards},$$
$$CA = 588 \text{ yards},$$
$$ACB = 55° \ 40';$$

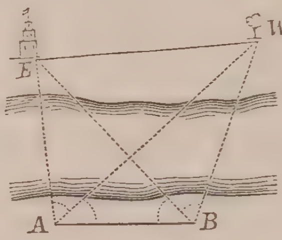
required the distance AB. *Ans.* 592.967 yards.

3. Being on a horizontal plane, and wanting to ascertain the height of a tower standing on the top of an inaccessible

hill, there were measured, the angle of elevation of the top of the hill 40°, and of the top of the tower 51°; then measuring in a direct line 180 feet farther from the hill, the angle of elevation of the top of the tower was 33° 45′: required the height of the tower.

Ans. 83.998.

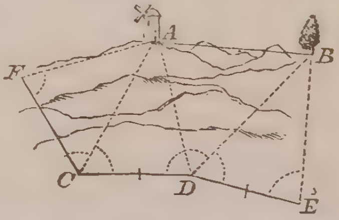
4. Wanting to know the horizontal distance between two inaccessible objects E and W, the following measurements were made.



$$\text{viz.,}\begin{cases} AB = 536 \text{ yards} \\ BAW = 40^\circ\ 16' \\ WAE = 57^\circ\ 40' \\ ABE = 42^\circ\ 22' \\ EBW = 71^\circ\ 07'; \end{cases}$$

required the distance EW. *Ans.* 939.634 yards.

5. Wanting to know the horizontal distance between two inaccessible objects A and B, and not finding any station from which both of them could be seen, two points C and D, were chosen at a distance from each other, equal to 200 yards; from the former of these points A could be seen, and from the latter B, and at each of the points C and D a staff was set up. From C a distance CF was measured, not in the direction DC, equal to 200 yards, and from D a distance DE equal to 200 yards, and the following angles taken,



$$\text{viz.,}\begin{cases} AFC = 83^\circ\ 00', & BDE = 54^\circ\ 30', \\ ACD = 53^\circ\ 30', & BDC = 156^\circ\ 25', \\ ACF = 54^\circ\ 31', & BED = 88^\circ\ 30'. \end{cases}$$

Ans. $AB = 345.467$ yards.

6. From a station P there can be seen three objects, A, B, and C, whose distances from each other are known: viz.,

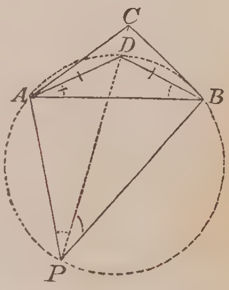
$$AB = 800, \quad AC = 600, \quad \text{and} \quad BC = 400 \text{ yards.}$$

Now, there are measured the horizontal angles,

$$APC = 33° \, 45', \text{ and } BPC = 22° \, 30':$$

It is required to find the three distances, PA, PC, and PB.

GEOMETRICALLY.



With the three given sides construct the triangle ABC. Then, at A lay off the angle $BAD = 22° \, 30'$, and at B the angle $ABD = 33° \, 45'$, and note D, the point at which the two lines intersect.

Through the points A, D, and B describe the circumference of a circle, and through C and D draw the line CDP; the point P in which it intersects the circumference, will be the position of the station.

By observing the equal angles in the figure, the trigonometrical solution is not difficult. We find,

$$Ans. \begin{cases} PA = 710.193 \text{ yards.} \\ PC = 1042.522 \quad \text{“} \\ PB = 934.291 \quad \text{“} \end{cases}$$

NOTE.—This problem is much used in maritime surveying, for the purpose of locating buoys and sounding-boats. The trigonometrical solution is somewhat tedious, but the geometrical solution is very easy, as shown above.

SECTION II.

AREA OR CONTENTS OF GROUND.

47. We come next to the determination of the area or superficial contents of ground.

The surface of ground being, in general, broken and uneven, it is impossible, without great trouble and expense, to ascertain its exact area or contents. To avoid this inconvenience, it has been agreed to refer every surface to a horizontal plane: that is, to regard all its bounding lines as horizontal, and its area as measured by that portion of the horizontal plane which the boundary lines enclose.

For example, if *ABCD* were a piece of ground, having an uneven surface, we should refer the whole to a horizontal plane, and take for the measure of the area that part of the plane which is included between the bounding horizontal lines *AB*, *BC*, *CD*, *DA*.

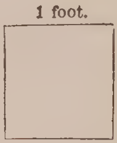
In estimating land in this manner, the sum of the areas of all the parts, into which a tract may be divided, is equal to the area, estimating it as an entire piece: but this would not be the case if the areas of the parts had reference to the *actual surface*, and the area of the whole were calculated from its bounding lines.

48. The unit of measure of any quantity is a quantity of the same kind, regarded as a standard. For lines, the unit is a right line of a known length, as 1 foot, 1 link, 1 chain, or any other fixed distance.

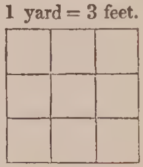
It has been already observed (Bk. II., Art. 18), that Gunter's chain of four rods or 66 feet in length, divided into 100 links, is the measure in general use among surveyors. In measuring land, the length of this chain is generally taken for the unit of linear measure.

49. The unit of measure for surfaces is a square described on the unit of linear measure.

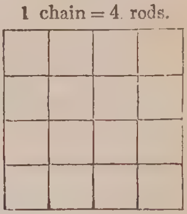
Thus, 1 square foot,



1 square yard or 9 square feet,



1 square chain, or 16 square rods.



When, therefore, the linear measures are feet, yards, rods, or chains, the superficial measures, are square feet, square yards, square rods, or square chains; and the numerical expression for the area, is the number of times which the unit of superficial measure is contained in the land measured.

50. An Acre, which is the common unit of measure for land, is a surface equal in extent to 10 square chains; that is, equal to a rectangle of which one side is ten chains and the other side one chain.

A Rood, is one quarter of an acre.

Since the chain is four rods in length, 1 square chain contains 16 square rods; and therefore, an acre, which is 10 square chains, contains 160 square rods, and a rood contains 40 square rods. A *square* rod is called a *perch.*

51. Land is generally computed in acres, roods, and perches; which are respectively designated by the letters *A. R. P.*

When the linear dimensions of a survey are chains or links, the area will be expressed in square chains or square links, and it is necessary to form a rule for reducing such area to acres, roods, and perches. For this purpose, let us form the following

TABLE.

Miles.	Acres.	Roods.	Sq. Chains.	Perches.	Sq. Links.
1	640	2560	6400.0	102,400	64,000,000
	1	4	10.0	160	100,000
		1	2.5	40	25,000
			1.0	16	10,000
				1	625

1 square mile = 6400 square chains = 640 acres.

When the linear dimensions are links, the area will be expressed in square links, and may be reduced to acres by dividing by 100,000, the number of square links in an acre: that is, by pointing off *five* decimal places from the right hand.

If the decimal part be then multiplied by 4, and five places of decimals pointed off, in the product, from the right hand, the figures to the left will express the roods.

If the decimal part of this result be now multiplied by 40, and five places for decimals pointed off, as before, the figures to the left will express the perches.

If one of the dimensions be in links, and the other in chains, the chains may be reduced to links by annexing two ciphers: or, the multiplication may be made without annexing the ciphers, and the product reduced to acres and decimals of an acre, by pointing off three decimal places from the right hand.

When both the dimensions are in chains, the product is reduced to acres by dividing by 10, or pointing off one decimal place.

From which we conclude; that,

1st. *If links be multiplied by links, the product is reduced to acres by pointing off five decimal places from the right hand.*

2d. *If chains be multiplied by links, the product is reduced to acres by pointing off three decimal places from the right hand.*

3d. *If chains be multiplied by chains, the product is reduced to acres by pointing off one decimal place from the right hand.*

52. Since there are 16.5 feet in a rod, a square rod is equal to $16.5 \times 16.5 = 272.25$ square feet.

If the last number be multiplied by 160, we shall have,

$272.25 \times 160 = 43560 =$ the square feet in an acre.

Since there are 9 square feet in a square yard, if the last number be divided by 9, we obtain,

$4840 =$ the number of square yards in an acre.

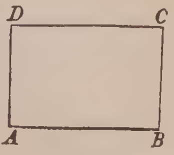
PROBLEM I.

53. To find the area of a piece of ground in the form of a square, rectangle, or parallelogram.

RULE.—*Multiply the base by the altitude, and the product will express the area* (Geom., Bk. IV., Prop. IV.)

EXAMPLES.

1. To find the area of the rectangular field *ABCD*.



Measure the two sides *AB*, *BC*: let us suppose that we have found $AB = 14$ chains 27 links, and $BC = 9$ chains 75 links. Then,

$$\begin{array}{rrl} & AB = 1427 & \text{links,} \\ & BC = 975 & \text{links,} \\ \cline{2-2} AB \times BC = & 1391325 & \text{square links,} \\ = & 13.91325 & \text{acres.} \\ & 4 & \\ \cline{2-2} & 3.65300 & \text{roods,} \\ & 40 & \\ \cline{2-2} & 26.12000 & \text{perches.} \\ \cline{2-2} \end{array}$$

Ans. 13 *A.* 3 *R.* 26 *P.*

2. What is the area of a square field, of which the sides are each 33 ch. 8 l.? *Ans.* 109 *A.* 1 *R.* 29 *P.*

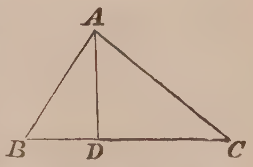
3. What are the contents of a rectangular field, of which the longer side is 49 ch. 27 l., and the shorter 38 ch. 7 l.? *Ans.* 187 *A.* 2 *R.* 11 *P.*

4. What are the contents of a field in the form of a parallelogram, of which the base is 35 ch. 65 l., and altitude 51 ch. 4 l.? *Ans.* 181 *A.* 3 *R.* 33 *P.*

PROBLEM II.

54. To find the contents of a piece of land in the form of a triangle.

FIRST METHOD.



RULE.—*Measure either side of the triangle as BC, and from the opposite angle A, let fall a perpendicular AD, and measure this perpendicular; then, multiply the base and perpendicular together, and divide the product by 2: the result will express the area of the triangle. Or, the area is equal to the base multiplied by half the perpendicular, or to the perpendicular multiplied by half the base* (Geom., Bk. IV., Prop. VI.)

EXAMPLES.

1. What are the contents of a triangle whose base is 25 ch. 1 l., and perpendicular 18 ch. 14 l.? *Ans.* 22 *A.* 2 *R.* 29 *P.*

2. What are the contents of a triangle whose base is 15.48 chains, and altitude 9.67 chains? *Ans.* 7 *A.* 1 *R.* 38 *P.*

SECOND METHOD.

RULE.—*Measure two sides and their included angle. Then, add together the logarithms of the two sides and the logarithmic sine of their included angle; from this sum subtract the logarithm of the radius, which is* 10, *and the remainder will be the logarithm of double the area of the triangle. Find, from the table, the number answering to this logarithm, and divide it by* 2: *the quotient will be the required area* (Geom. Mens., Art. **96**).

EXAMPLES.

1. In a triangle ABC, suppose that we have found $AB = 57.65$ ch., $AC = 125.81$ ch., and the included angle $CAB = 57° 25'$: required the area?

Let the required area be designated by Q; then,

$$\log 2\,Q = \left\{\begin{array}{lll} + \log AB & 57.65 \;.\;.\;.\;. & 1.760799 \\ + \log AC & 125.81 \;.\;.\;.\;. & 2.099715 \\ + \log \sin A & 57^\circ\, 25' \;.\;.\;.\;. & 9.925626 \\ - \log R & .\;.\;.\;.\;.\;.\;.\;. & 10 \end{array}\right.$$

$$\begin{array}{lll} 2\,Q & = 6111.4 \;.\;.\;.\;.\;.\;.\;.\;. & \underline{\overline{3.786140}} \\ \text{And}\quad Q & = 3055.7 \text{ square chains.} & \end{array}$$

Ans. 305 *A.* 2 *R.* 11 *P.*

NOTE.—In this example, the links are treated as decimal parts of the chain; the result, therefore, is in square chains and decimal parts of a square chain.

2. What is the area of a triangle whose sides are 30 and 40 chains, and their included angle 28° 57′?

Ans. 29 *A.* 0 *R.* 7 *P.*

THIRD METHOD.

RULE.—*Measure the three sides of the triangle. Then, add them together and take half their sum. From this half sum subtract each side separately. Then, multiply the half sum and the three remainders together, and extract the square root of the product: the result will be the area* (Geom. Mens., Art. **97**).

Or, after having obtained the three remainders, add together the logarithm of the half sum and the logarithms of the respective remainders, and divide their sum by 2: the quotient will be the logarithm of the area.

EXAMPLES.

1. Find the area of a triangular piece of ground whose sides are 20, 30, and 40 chains.

BY FIRST RULE.

$$\begin{array}{rrrr} 20 & 45 & 45 & 45 \\ 30 & -\underline{20} & -\underline{30} & -\underline{40} \\ \underline{40} & \underline{25}\text{ 1st rem.} & \underline{15}\text{ 2d rem.} & \underline{5}\text{ 3d rem.} \\ \underline{2)90} & & & \\ 45 = \text{half sum.} & & & \end{array}$$

Then,

$45 \times 25 \times 15 \times 5 = 84375$: and $\sqrt{84375} = 290.4737 =$ the area.

Ans. 29 *A.* 0 *R.* 8 *P.*

2. What is the area of a triangle whose sides are 2569, 4900, and 5035 links?

BY SECOND RULE.

$$\begin{array}{rrrr} 2569 & 6252 & 6252 & 6252 \\ 4900 & -\underline{2569} & -\underline{4900} & -\underline{5035} \\ \underline{5035} & \underline{3683}\text{ 1st rem.} & \underline{1352}\text{ 2d rem.} & \underline{1217}\text{ 3d rem.} \\ \underline{2)12504} & & & \\ \underline{6252} = \text{half sum.} & & & \end{array}$$

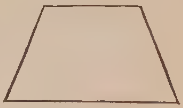
Then, log 6252 . . . . 3.796019
log 3683 . . . . 3.566202
log 1352 . . . . 3.130977
log 1217 . . . . 3.085291
2)13.578489
Area in square links, 6155225 . . . 6.789244
Ans. 61 *A.* 2 *R.* 8 *P.*

PROBLEM III.

55. **To find the area of a piece of land in the form of a trapezoid.**

RULE.—*Measure the two parallel sides, and also the perpendicular distance between them. Add the two parallel sides together, and take half the sum; then multiply the half sum by the perpendicular, and the product will be the area* (Geom., Bk. IV., Prop. VII.)

EXAMPLES.



1. What is the area of a trapezoid, of which the parallel sides are 30 and 49 chains, and the perpendicular distance between them 16 ch. 60 l., or 16.60 chains?

30 + 49 = 79; dividing by 2, gives 39.5
multiply by 16.60
area in square chains . . . . 655.700.

Ans. 65 *A.* 2 *R.* 11 *P.*

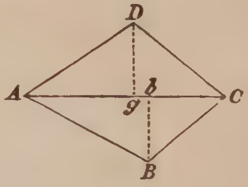
2. Required the contents, when the parallel sides are 20 and 32 ch., and the perpendicular distance between them 26 ch. *Ans.* 67 *A.* 2 *R.* 16 *P.*

PROBLEM IV.

56. **To find the area of a piece of land in the form of a quadrilateral.**

RULE.—*Measure the four sides of the quadrilateral, and also one of the diagonals: the quadrilateral will thus be divided into* *two triangles, in both of which all the sides will be known. Then, find the areas of the triangles separately, and their sum will be the area of the quadrilateral.*

EXAMPLES.



1. Suppose that we have measured the sides and diagonal AC, of the quadrilateral $ABCD$, and found

$AB = 40.05$ ch. $CD = 29.87$ ch.,

$BC = 26.27$ ch. $AD = 37.07$ ch.,

and $AC = 55$ ch.:

required the area of the quadrilateral.

Ans. 101 *A.* 1 *R.* 15 *P.*

NOTE.—Instead of measuring the four sides of the quadrilateral, we may let fall the perpendiculars Bb, Dg, on the diagonal AC. The area of the triangle may then be determined by measuring these perpendiculars and the diagonal AC. The perpendiculars are $Dg = 18.95$ ch., and $Bb = 17.92$ ch.

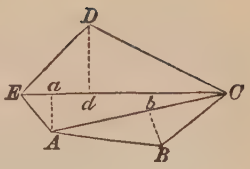
PROBLEM V.

57. To find the contents of a field having any number of sides.

RULE.—*Measure the sides of the field and also the diagonals: the three sides of each of the triangles into which the field will be thus divided will then be known, and the areas of the triangles may then be calculated by the preceding rules.* Or, *measure the diagonals, and from the angular points of the field draw perpendiculars to the diagonals and measure their lengths: the base and perpendicular of each of the triangles will then be known.*

EXAMPLES.

1. Let it be required to determine the contents of the field $ABCDE$, having five sides.



Let us suppose that we have measured the diagonals and perpendiculars, and found,

$AC = 36.21$ ch., $EC = 39.11$ ch.,
$Bb = 4.08$ ch., $Dd = 7.26$ ch.,
$Aa = 4.19$ ch.: required the area of the field.

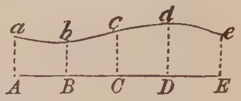
Area of triangle $ABC = 73.8684$ square chains,
area of " $CDE = 141.9693$ " "
area of " $ACE = \underline{81.7399}$ " "
area of $ABCDE = \underline{297.5776}$ " "

Ans. 29 *A.* 3 *R.* 1 *P.*

PROBLEM VI.

58. To find the contents of a long and irregular figure, bounded on one side by a straight line.

Suppose the ground, of which the contents are required, to be of the form *ABEeda*, bounded on one side by the right line *AE*, and on the other by the curve *abcde.*



At *A* and *E*, the extremities of the right line *AE*, erect the two perpendiculars *Aa*, *Ee*, and on each of them measure the breadth of the land. Then divide the base into any convenient number of equal parts, and measure the breadth of the land at each point of division.

Since each part of the entire area, as *ABba*, is a trapezoid having an equal altitude—viz., the equal distance between any two of the perpendiculars; and since the area of each trapezoid is equal to half the sum of its parallel sides multiplied by the distance between them; and since the sum of these areas make up the area of the whole figure; and since, in this sum, each perpendicular, except the extreme ones, is taken twice, and they but once; and since the distance between any two perpendiculars is a common multiplier of each part; therefore, for the entire area, we have the following

RULE.—*Add together the intermediate breadths and half the sum of the two extreme ones: then multiply this sum by one of the equal parts of the base-line, and the product will be the required area very nearly.*

EXAMPLES.

1. The breadths of an irregular figure, at five equidistant places, being 8.20 ch., 7.40 ch., 9.20 ch., 10.20 ch., and 8.60 chains, and the whole length 40 chains, required the area

8.20
8.60
2)16.80
8.40 mean of the extremes,
7.40
9.20
10.20
35.20 sum.

4)40
10 one of the equal parts.

35.20 sum,
10
area 352.00 square ch.

Ans. 35 *A.* 32 *P.*

2. The length of an irregular piece of land being 21 ch., and the breadths, at six equidistant points, being 4.35 ch., 5.15 ch., 3.55 ch., 4.12 ch., 5.02 ch., and 6.10 chains: required the area. *Ans.* 9 *A.* 2 *R.* 30 *P.*

3. The length of an irregular piece of land is 80 ch., and the breadths at nine equidistant points are 5.75 ch., 6.12 ch., 4.80 ch., 5.09 ch., 3.87 ch., 5.17 ch., 6.00 ch., 3.94 ch., and 5.95 ch.: what is the area? *Ans.* 40 *A.* 3 *R.* 14 *P.*

4. The length of an irregular field is 39 rods, and its

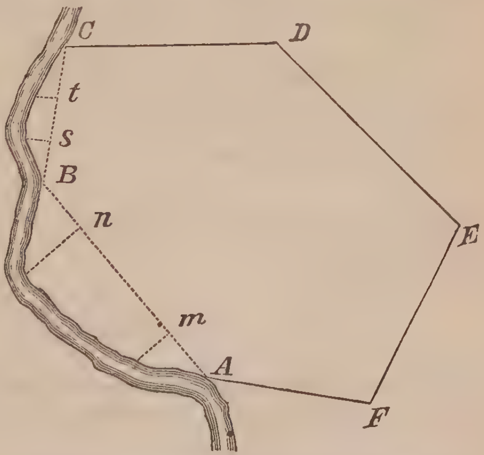
breadths at five equidistant places are 4.8, 5.2, 4.1, 7.3, and 7.2 rods: what is its area? *Ans.* 220.35 sq. rods.

NOTE.—If it is not convenient to erect the perpendiculars at equal distances from each other, the areas of the trapezoids, into which the whole figure is divided, must be computed separately: their sum will be the required area.

PROBLEM VII.

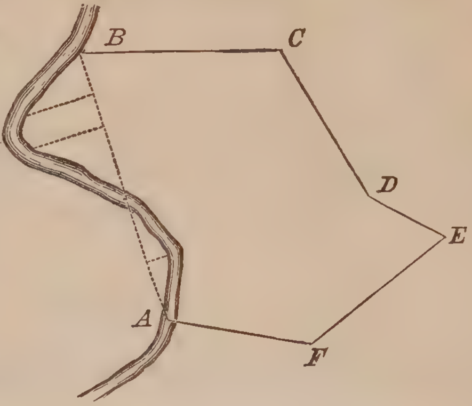
59. To find the contents when the boundary is an irregular line.

It frequently happens that a plot to be surveyed is bounded partly by an irregular line. In such a case, one or more straight lines are surveyed, and offsets measured from these lines, as often as may be required to afford data for the computation of the area, and a true delineation of the boundary. In the case represented in the figure, the stream from *A* to *C* is the boundary. The station *B* is selected for convenience as it is evident, if the line were run direct from *A* to *C*, the labor of taking the offsets would be much greater.



It will be observed that the offsets are so measured as to indicate the abrupt bends in the boundary; and furthermore, so that the areas thus cut off may be considered as being bounded by straight lines, without sensible error.

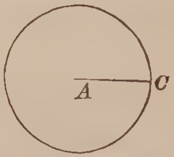
60. When the boundary is a crooked stream that is easily crossed, it is often convenient to survey a line across the bend, as in the figure, and locate by offsets upon both sides of the line. In any case, the small areas to be computed are only trapezoids and triangles.



PROBLEM VIII.

61. To find the area of a piece of ground in the form of a circle.

RULE.—*Measure the radius AC: then multiply the square of the radius by* 3.1416 (Mens., Art. **105**).

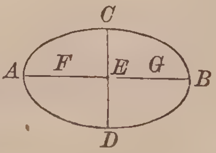


To find the area of a circular piece of land, of which the diameter is 25 ch. *Ans.* 49 *A.* 0 *R.* 14 *P.*

PROBLEM IX.

62. To find the contents of a piece of ground in the form of an ellipse.

RULE.—*Measure the semi-axes AE, CE. Then multiply them together, and their product by* 3.1416.



To find the area of an elliptical piece of ground, of which the transverse axis is 16.08 ch., and the conjugate axis 9.72 ch. *Ans.* 12 *A.* 1 *R.* 4 *P.*

NOTE 1.—The following is the manner of tracing an ellipse on the ground, when the two axes are known.

From C, one of the extremities of the conjugate axis as a centre, and AE, half the transverse axis, as a radius, describe the arc of a circle cutting AE in the two points F and G: these points are called the *foci* of the ellipse.

Then, take a tape, the length of which is equal to AB, and fasten the two ends, one at the focus F, the other at the focus G. Place a pin against the tape and move it around, keeping the tape tightly stretched: the extremity of the pin will trace the curve of the ellipse.

NOTE 2.—In determining the contents of ground, in the examples which have been given, the linear dimensions have been taken in chains and decimals of a chain.

If the linear dimensions were taken in terms of any other unit, they may be readily reduced to chains. For, a chain is equal to 4 rods, equal to 22 yards, equal to 66 feet. Hence,

1st. *Rods may be reduced to chains and the decimal of a chain, by dividing by* 4.

2d. *Yards may be reduced to chains and the decimal of a chain, by dividing by* 22.

3d. *Feet may be reduced to chains and the decimal of a chain, by dividing by* 66.

NOTE 3.—If it is thought best to calculate the area, without reducing the linear dimensions to chains, the result can be reduced to acres:

1st. *By dividing it by* 160, *when it is in square rods* (Art. **50**).

2d. *By dividing it by* 4840, *when it is in square yards* (Art. **52**).

3d. *By dividing it by* 43560, *when it is in square feet* (Art. **52**).

SECTION III.

COMPASS SURVEYING.

63. The Axis of the earth is the immovable diameter about which it revolves; and the *poles* are the points in which the axis meets the surface.

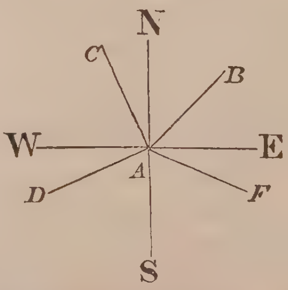
64. Any plane passing through the axis of the earth is called a *meridian plane;* and its intersection with the surface is called a *meridian line,* or simply a *meridian.*

65. All the meridians converge towards the poles, but they vary so little from parallelism, within the narrow limits of surveys made with the compass, that they may, without sensible error, be regarded as parallel straight lines.

66. If a magnetic needle be suspended freely, and allowed to settle to a state of rest, a vertical plane passed through its axis is called the *plane of the magnetic meridian;* and its intersection with the surface of the earth is called the *magnetic meridian,* or sometimes, a North and South line. A line perpendicular to a North and South line, is called an *East* and *West* line.

67. A line traced, or measured on the ground, is called a *Course;* and the angle which this line makes with the magnetic meridian, passing through the point of beginning, is called the *Bearing.*

Thus, if we start from the point *A*, and measure in the direction *AB*, the line *AB* is the course, and the angle *NAB*, is the bearing.



When the course, like *AB*, falls between the north and east points, and makes an angle of 46° with the meridian, the bearing is read, north 46° east, and is written, N. 46° E.

When the course, like *AC*, falls between the north and west points, and makes with the meridian an angle of 30°, the bearing is read, north 30° west, and is written, N. 30° W.

When the course, like *AD*, falls between the south and west points, and makes an angle with the meridian of 70°, the bearing is read, south 70° west, and is written, S. 70° W.

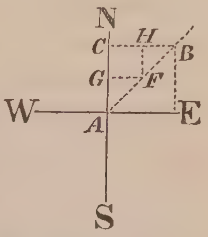
When the course, like *AF*, falls between the south and east points, and makes with the meridian an angle of 70°, the bearing is read, south 70° east, and is written, S. 70° E.

A course which runs due north, or due south, is designated by the letter N, or S; and one which runs due east, or due west. by the letter E, or W.

68. If, after having passed over a course, the bearing is taken to the back station, this bearing is called the *back sight*, or *reverse bearing.*

69. The perpendicular distance between the east and west lines, drawn through the extremities of a course, is called the *northing* or *southing*, according as the course is run towards the north or south. This distance is also called the *difference of latitude*, or simply the latitude, because it shows the distance which one end of the course is north or south of the other.

Thus, in running the course from *A* to *B*, *AC* is the difference of latitude, north.



70. The perpendicular distance between the meridians passing through the extremities of a course, is called the *departure* of that course, and is east or west, according as the course lies on the east or west side of the meridian passing through the point of beginning.

Thus, in running the course *AB*, *CB* is the departure, east.

71. It is found convenient, in explaining the rules for surveying with the compass, to attribute to the latitudes and departures, the algebraic signs, + and −.

We shall, therefore, consider every northing as affected with the sign +, and every southing as affected with the sign −. We shall also consider every easting as affected with the sign +, and every westing as affected with the sign −.

72. The *meridian distance* of a point is its perpendicular distance from any assumed meridian. Thus, if the distance be estimated from the meridian NS, *BC* will be the meridian distance of the point *B*.

73. The meridian distance of a *line*, is the meridian distance of its *middle point*, and is east or west, according as this point lies on the east or west side of the assumed meridian. Thus, *FG* drawn through the middle point of *AB*, is the meridian distance of the line *AB*.

The sign + will always be given to the meridian distance of a point or line, when it lies on the east of the assumed meridian, and the sign −, when it lies on the west.

SURVEYOR'S COMPASS.

74. This instrument (Pl. 2, Fig. 2), consists of a compass-box *DCE*, a magnetic needle, a brass plate *AB*, from twelve to fourteen inches long, two plain sights, *AF* and *BG*, one of which is more fully shown in Fig. 3; and a stand, which is sometimes a tripod, and sometimes a single staff, pointed with iron at the lower end, so that it may be placed firmly in the ground.

The open sights, *AF* and *BG*, are placed at right angles to the plate *AB*, and fastened to it firmly by the screws *a* and *b*. In each sight there is a large and small aperture or slit; the larger aperture being above the smaller in one of the sights, and below it in the other. A hair or thread of silk is drawn vertically through the middle of the large aperture, as shown in Fig. 3.

The compass-box *DCE* is circular, and generally about six inches in diameter. At the centre is a small pin, on which the magnetic needle is poised. This needle, if allowed to turn freely around the point of support, will settle to a state of rest: the direction which it then indicates, is that of the *magnetic meridian.*

In the interior of the compass-box, there is a graduated circle divided to degrees, and sometimes to half degrees: the degrees are numbered from the extremities of the diameter NS, both ways to 90°.

The length of the magnetic needle is a little less than the diameter of the graduated circle, so that the needle can move freely around its centre, within the circle, and its positions be noted on the graduated arc.

The compass-box is turned about its centre, without moving the plate *AB*, by means of the milled screw *L:* and is fastened to the plate *AB*, by the screw *P*.

In using the compass, it is important to ascertain the exact angle which may be included between the magnetic meridian and the course. The course is always indicated by the line drawn through the eye and the sights *AF* and *BG*.

To measure this angle, accurately, a small arc *HI* is described on the bar *AB*, having its centre at the centre of the compass-box. This arc is divided to degrees, and sometimes to the parts of a degree. A vernier is also used, which is permanently attached to the compass-box.

When the 0 point of this vernier coincides with the 0 point of the graduated arc *HI*, the line of the compass-box marked NS, lies in the plane of the sights.

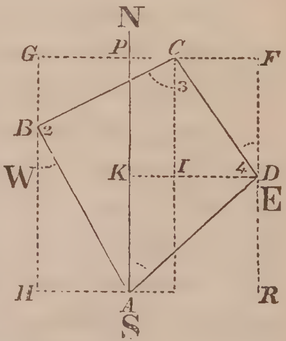
Suppose the 0 of the vernier to coincide with the 0 of the arc *HI*. If the end of the needle does not stand at one of the lines of division of the graduated circle, let the whole degrees be read. Then, turn the compass-box by means of the screw *L*, until the needle points exactly to the line which marked the whole degrees: the space passed over by the 0 of the vernier, shows the parts of a degree that are to be added, to give the true reading.

WORK ON THE FIELD.

75. When a piece of ground is to be surveyed, we begin at some prominent corner of the field, and go entirely around the land, measuring the lengths of the bounding lines with the chain, and taking their bearings with the compass. It is not material whether the ground be kept on the right hand or on the left, and all the rules deduced for one of the cases, are equally applicable to the other. To preserve uniformity, however, in the language of the rules, we shall suppose the land to be always kept on the right hand of the surveyor.

Let *ABCD* be a piece of ground to be surveyed, *A* the point where the work is to be begun, and NS a meridian.

On a sheet of paper, rule three columns, as follows, and head them stations, bearings, distances.



Stations.	Bearings.	Distances.
1	N 31½° W	10.40
2	N 62° E	9.20
3	S 36° E	7.60
4	S 45½° W	10.00

Place the compass at *A*, and take the bearing to *B*, which is *PAB:* suppose this angle has been found to be 31½°.

The bearing from *A* to *B* is then N. 31½° W. Enter this bearing in the field notes opposite station 1. Then measure the distance from *A* to *B*, which we will suppose to be 10 ch. 40 l., and insert that distance opposite station 1, in the column of distances.

We next take the bearing from *B* to *C*, N. 62° E., and then measure the distance $BC = 9$ ch. 20 l., both of which we insert in the notes opposite station 2.

At station *C* we take the bearing to *D*, S. 36° E., and then measure the distance $CD = 7$ ch. 60 l., and place them in the notes opposite station 3..

At *D* we take the bearing to *A*, S. 45½° W., and measure the distance $DA = 10$ ch. We shall then have made all the measurements on the field which are necessary to determine the contents of the ground.

PRINCIPLES.

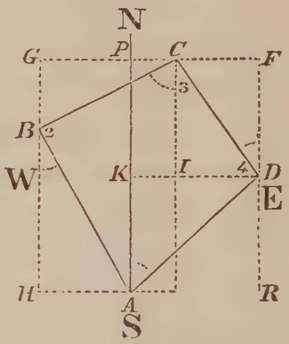
76. The reverse-bearing or back-sight, from *B* to *A*, is the angle *ABH;* and since the meridians NS and *HG* are parallel, this angle is equal to the bearing *NAB*. The reverse-bearing is, therefore, S. 31½° E.

The reverse-bearing from *C*, is S 62° W.; that is, it is the angle $ICB = GBC$. And generally,

A reverse-bearing, or back-sight, is always equal to the forward-bearing, and differs from it only in both of the letters by which it is designated.

77. In taking the bearings with the compass, there are two sources of error. 1st. The inaccuracy of the observations: 2d. Local attractions, or the derangement which the needle experiences when brought into the vicinity of iron-ore beds, or any ferruginous substances.

To guard against these sources of error, the reverse-bearing should be taken at every station: if this and the forward-bearing are of the same value, the work is probably right; but if they differ considerably, they should both be taken again.



78. In passing over the course *AB*, the northing is found to be *HB*, and the departure, which is west, is represented by *AH*. Of the course *BC*, the northing is expressed by *BG*, and the departure, which is east, by *GC*. Of the course *CD*, the southing is expressed by *CI*, and the departure, which is east, by *CF*. Of the course *DA*, the southing is expressed by *KA*, and the departure, which is west, by *DK*. It is seen from the figure, that the sum of the northings is equal to $HB + BG = HG$; and that the sum of the southings is equal to $CI + KA = PA = HG$: hence, *the sum of the northings is equal to the sum of the southings.*

If we consider the departures, it is apparent that the sum of the eastings is equal to $GC + CF = GF$; and that the sum of the westings is equal to $AH + DK = GF$: hence, *the sum of the eastings is equal to the sum of the westings.* We therefore see, that when the survey is correct, *the sum of the northings will be equal to the sum of the southings, and the sum of the eastings to the sum of the westings.*

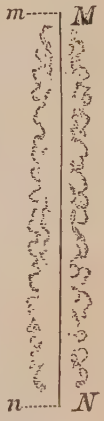
It would, indeed, appear plain, even without a rigorous demonstration, that after having gone entirely round a piece of land, the distance passed over in the direction due north must be equal to that passed over in the direction due south; and that the distance passed over in the direction due east must be equal to that passed over in the direction due west.

79. The boundaries of a field are generally occupied by fences, and frequently also by a border of shrubbery, so that chaining along the true boundary is impossible.

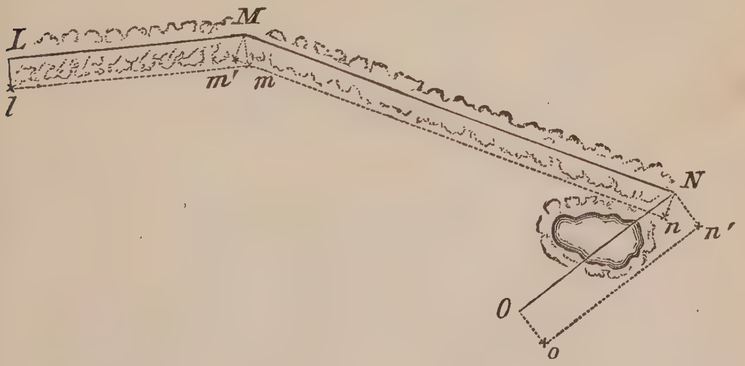
In such cases, it becomes necessary to measure an offset at each end of the course (and at right angles to it), and of sufficient length to clear the obstructions; the measurement is then made between these temporary stations.

It is evident that the bearing and length of *mn*, the offset-course, are the same as those of *MN*.

When such offset-courses are necessary for several successive courses, errors are likely to be committed, unless the surveyor is careful to make new offsets for each course.



The offset-courses, for the lines *LM*, *MN*, and *NO*, are respectively *lm*, *m'n*, and *n'o*.



Such offsets, in field surveys, may generally be measured by the flag-staff, and the right angle may be determined with sufficient accuracy by the eye.

It is, of course, immaterial, so far as accuracy is concerned, upon which side of the line the offset is taken, whether it be outside or inside the field.

80. It has been customary, since the first settlement of this country, to use the compass in all land surveys, so that the description of lands, in purchase and sale, and by which they are recognized in the courts, involves the length and bearing of each straight line of the boundary. The method, therefore, is, at present, a necessary one.

The errors to which the compass is liable are so numerous and so variable, even in the same instrument, that a change of practice is very desirable. Many surveyors, to insure a higher degree of accuracy, measure the angles of a field with the theodolite or transit, and then, having determined the bearing of one side with sufficient accuracy, calculate the others by a method to be shown in a subsequent article.

81. In surveys of large areas, the surveying party should consist of at least four persons—viz., a compass-man, a flag-man, and two chain-men. In smaller areas, the work is generally performed by the surveyor and one assistant; the surveyor serving alternately as compass-man and hind-chainman, and the assistant as flag-man and fore-chainman.

82. The best method of recording the notes of the survey of any line, from which numerous offsets are measured, is to record the distances along the line in a central column of the left-hand page of the note-book, beginning the record at the bottom of the page, and reserving each right-hand page for a diagram of the survey, and such remarks as are necessary.

The advantage of beginning at the bottom of the page is this: that when standing on the line to be surveyed, and looking in the direction we propose to go, the column in the book lies before us just as the line does, and all measurements made to the right or left of the line are recorded at the right or left of the column. In surveys where many auxiliary notes are taken, a diagram is an important aid to a ready interpretation of the other notes.

General Example.

83. To explain the method, in full, of making a compass survey and recording the notes, we will take an example of a farm, in which, in addition to the usual survey of the boundary, such other measurements are made as to enable us to make a correct map of the whole.

Page 119, represents a farm to be surveyed, and page 118, the notes which are made, in the operations on the field.

Beginning with the corner marked *A*, the bearing of the line *AB*, is taken. In most cases, offsets from both *A* and *B* would be taken, in order that the survey may be clear of the fence, but such offsets are not recorded.

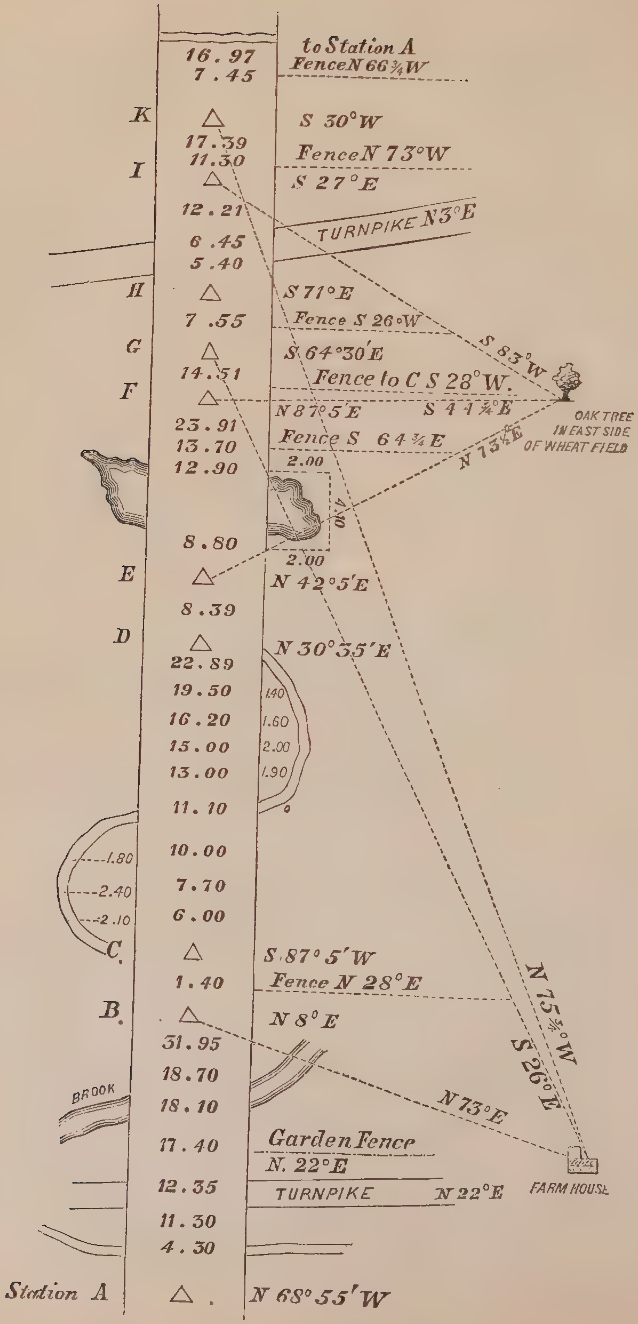
The record of the bearing of the first course is entered at the right of the column (page 118), while the letter designating the station, is placed to the left.

The symbol △, which signifies station, is placed in the column, between the letter and the bearing, for each angle of the farm.

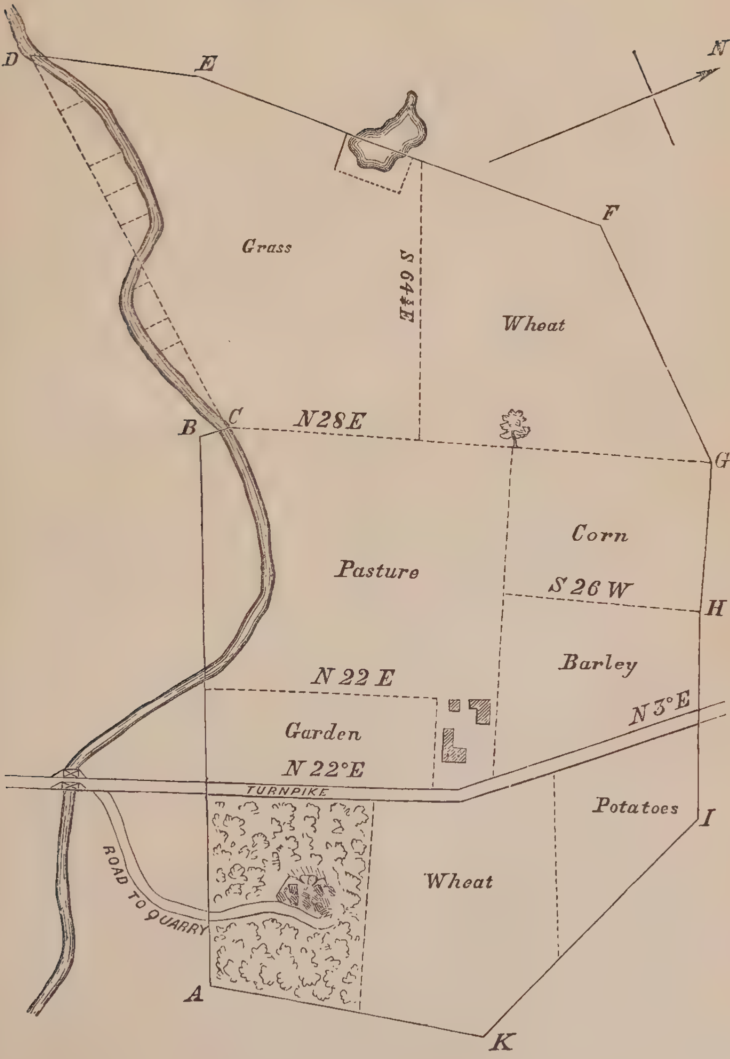
In chaining the first course, the intersection of the line with any objects worthy of notice is recorded. The first record is of the road leading to the quarry. As it is an unimportant road, a single measurement of the distance on the course to its centre is sufficient to locate it. The distance is 4.30 chains.

At 11.30 and 12.35 the sides of the turnpike are intersected. The bearing of the road, at this point, is also carefully taken and recorded.

The intersections of the Garden fence and of the brook are also noted (17.40) and (18.10); and these, with the entire length of the course (31.95), close the record of this line.


to Station A
16.97
Fence N 66¾ W
7.45
K
S 30° W
17.39
Fence N 73° W
11.30
I
S 27° E
12.21
TURNPIKE N 3° E
6.45
5.40
H
S 71° E
7.55
Fence S 26° W
S 83° W
G
S 64° 30′ E
14.51
Fence to C S 28° W.
F
N 87° 5′ E
S 44¾° E
OAK TREE IN EAST SIDE OF WHEAT FIELD
23.91
Fence S 64¾ E
N 73¾° E
13.70
12.90
2.00
4.00
8.80
2.00
E
N 42° 5′ E
8.39
D
N 30° 35′ E
22.89
19.50
1.40
16.20
1.60
15.00
2.00
13.00
1.90
11.10
10.00
1.80
7.70
2.40
6.00
2.10
C.
S 87° 5′ W
1.40
Fence N 28° E
B.
N 8° E
31.95
18.70
N 75¾° W
S 26° E
BROOK
18.10
N 73° E
17.40
Garden Fence
N. 22° E
12.35
TURNPIKE
N 22° E
FARM HOUSE
11.30
4.30
Station A
N 68° 55′ W

MAP OF FARM.


N
D
E
F
Grass
S 64¾E
Wheat
B
C
N28E
G
Corn
Pasture
S 26 W
H
Barley
N 22 E
N 3° E
Garden
N 22°E
TURNPIKE
Potatoes
I
ROAD TO QUARRY
Wheat
A
K

At *B*, the bearing of the northernmost chimney of the farm-house is taken (N. 73° E.) Such bearings serve two purposes. They aid in the location of the objects observed, upon the map, and serve also, in case of errors, to aid in detecting their location.

In general, in surveying large or small areas, some prominent point or points, within the boundary, should be selected, and their bearings, from different angles, carefully noted.

The chimney of the farm-house and the oak-tree in the corner of the wheat-field, are thus employed in this survey.

At *C*, the corner of the field, is in the centre of the brook, and from this point to *D*, the brook is the boundary. A straight line is run between the stations, and offsets are measured to each bend of the brook.

It is necessary, in such a case, for the chainmen to exercise unusual care in keeping in the line between the stations, otherwise the lengths of the offsets cannot be correctly measured.

At *E*, the bearing of the oak-tree is taken (N. $73\frac{1}{2}$° E.) On the course between *E* and *F*, a marsh is encountered, which the chainmen pass, by an offset course.

At *F*, another bearing is taken of the oak-tree (S. $44\frac{1}{4}$° E.)

At *G*, the bearing of the farm-house chimney is noted (S. 26° E.) At *G* and *H* the bearings of the division-fences are taken. On the course from *H* to *I*, the turnpike is again crossed: the intersection of both sides, together with the bearing, are carefully noted.

From *I* to *K*, the intersection and bearing of the fence between the potato and the wheat field, are recorded. The course from *K* to *A* closes the survey.

To locate the buildings about the farm-house, a few measurements would be necessary; but they may begin with the point already located by the bearings taken to the chimney nearest the north end of the house.

The dimensions of the buildings, their distances apart, and the direction of one side of each being taken, sufficient data is afforded for locating them, correctly, upon the map.

NOTE.—The advantage of the compass over other instruments with which angles are measured, lies chiefly in this: that the Bearing of a course may be measured at any point on the line.

When the angle between adjacent sides is taken with the Transit or Theodolite, the work can only be done at the corners of the field; and when, as frequently happens, a hill intervenes between two consecutive stations, it becomes necessary to locate a point on the hill, in the true line, and then return to the corner to measure the angle; whereas, when the compass is employed, the establishment of the intermediate point on the hill affords the means of taking the proper bearing without going to the angle. Furthermore, the bearings may be measured with the compass, by placing it at the alternate stations only.

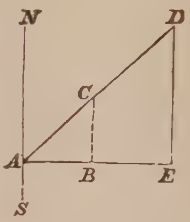
CONTENTS OF GROUND.

84. Having explained the necessary operations on the field, we shall now proceed to show the manner of computing the contents of ground.

THE TRAVERSE TABLE AND ITS USES.

85. This table shows the latitude and departure corresponding to bearings that are expressed in degrees and quarters of a degree, from 0 to 90°, and for every course from 1 to 100, computed to two places of decimals.

The following is the method of deducing the formulas for computing a traverse table; by means of these formulas and a table of natural sines, the latitude and departure of a course may be computed to any desirable degree of accuracy.



Let AD represent any course, and $NAD = ACB$, expressed in degrees and minutes, be its bearing. Let AC be the unit of measure of the course, and also the radius of the table of natural sines (Bk. I., Sec. III., Art. 57). Draw DE and CB parallel to NS, and AE perpendicular to AS. Then will DE be the *latitude*, and AE the *departure of the course*, and CB the *cosine*, and AB the *sine* of the *bearing*, to the radius $AC = 1$.

From similar triangles we have these proportions,

$$AC : CB :: AD : DE, \text{ or}$$

$$1 : \text{cos of the bearing} :: \text{course} : \text{latitude};$$

$$\text{and} \quad AC : AB :: AD : AE, \text{ or}$$

$$1 : \text{sin of the bearing} :: \text{course} : \text{departure}.$$

Whence,

$$\text{lat.} = \text{course} \times \text{cos of the bearing},$$

$$\text{dep.} = \text{course} \times \text{sin of the bearing}.$$

We have then the following practical rule for computing the latitude and departure of any course.

Look in a table of natural sines for the cosine and sine of the bearing. Multiply each by the length of the course, and the first product will be the latitude, and the second will be the departure of the given course.

EXAMPLES.

1. The bearing is 65° 39′, the course 69.41 chains: what is the latitude, and what the departure?

Natural cosine of 65° 39′	.41231
Length of the course	69.41
Product, which is the Dif. of Lat. . .	28.6184371
Natural sine of 65° 39′.	.91104
Length of the course	69.41
Product, which is the Departure . .	63.2352864

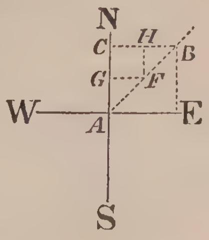
2. The bearing is 75° 47′, the course 89.75 chains: what is the latitude, and what the departure?

Natural cosine of 75° 47′	.24559
Length of course	89.75
Product, which is the Dif. of Lat. . .	22.0417025
Natural sine of 75° 47′.	.96937
Length of course	89.75
Product, which is the Departure . .	87.0009575

In this manner, the traverse table given at the end of the book, has been computed. When the bearing is given in degrees and quarters of a degree, and the difference of latitude and departure are required to only two places of decimals, they may be taken directly from the traverse table.

When the bearing is less than 45°, the angle will be found at the top of the page; when greater, at the bottom. When the distance is less than 50, it will be found in the column "distance," on the left-hand page; when greater than 50, in the corresponding column of the right-hand page.

86. The latitudes or departures of courses of different lengths, but which have the same bearing, are proportional to the lengths of the courses. Thus, in the figure, the latitudes *AG*, *AC*, or the departures *GF*, *CB*, are to each other as the courses *AF*, *AB*.



Therefore, when the distance is greater than 100, it may be divided by any number which will give an exact quotient, less than 100: then the latitude and departure of the quotient being found and multiplied by the divisor, the products will be the latitude and departure of the whole course. It is also plain, that the latitude or departure of two or more courses, having the same bearing, is equal to the sum of the latitudes or departures of the courses taken separately.

Hence, if we have any number greater than 100, as 614, we have only to recollect that, 610 + 4 = 614; and also, that the latitude and departure of 610, are ten times as great, respectively, as the latitude and departure of 61: that is, equal to the latitude and departure of 61 multiplied by 10; or, to such latitude and departure with the decimal point removed one place to the right.

EXAMPLES.

1. To find the latitude and departure for the bearing 29½°, and the course 614.

Latitude for 610 . . .	530.90	Departure for 610 . .	300.40
Latitude for 4 . . .	3.48	Departure for 4 . .	1.97
Latitude for 614 . . .	534.38	Departure for 614 . .	302.37

In this example, the latitude and departure answering to the bearing 29½°, and to the distance 61, are first taken from the table, and the decimal point removed one place to the right: this gives the latitude and departure for the distance 610; the latitude and departure answering to the same bearing and the distance 4, are then taken from the table and added.

2. To find the latitude and departure for the bearing 62½°, and the course 7855 chains.

Latitude for 7800	3602.00	Departure for 7800 .	6919.00
Latitude for 55 .	25.40	Departure for 55 .	48.79
Latitude for 7855 .	3627.40	Departure for 7855 .	6967.79

NOTE.—When the distances are expressed in whole numbers and decimals, the manner of finding the latitudes and departures is still the same, except in pointing off the places for decimals: but this is not difficult, when it is remembered that the column of distances in the table, may be regarded as decimals, by simply removing the decimal point to the left, in the other columns.

3. To find the latitude and departure for the bearing $47\frac{3}{4}°$, and the course 37.57.

Latitude for 37.00 . .	24.88	Departure for 37.00 .	27.39
Latitude for .57 . .	.38	Departure for .57 .	.42
Latitude for 37.57 . .	25.26	Departure for 37.57 .	27.81

BALANCING THE WORK.

87. Having explained the use of the traverse table, we can proceed to compute the area of the ground.

The field-notes having been completed, rule a new table, as on next page, with four additional columns, two for latitude, and two for departure.

Then find, from the traverse table, the latitude and departure of each course, and enter them in the proper columns opposite the station.

Then add up the column of northings, and also the column of southings: the two sums should be equal to each other. If they are not, subtract the less from the greater; the remainder is called the *error in latitude.* This error takes the name of that column which is the *least.* For example, if the sum of the northings is less than the sum of the southings, the error is called, *error in northing:* but if the sum of the southings is less than the sum of the northings, the error is called, *error in southing.* And similarly for the departures.

This error for latitude or departure must be distributed among the latitudes or departures of all the courses, in proportion to the length of each course, observing to *add* the correction, when applied to the deficient column, and to *subtract* it, when applied to the other.

We will illustrate this, by the example of (Art. **75**).

Stations.	Bearings.	Dis.	Dif. Lat.		Dep.		Balance.	
			N. +	S. −	E. +	W. −	Lat.	Dep.
1	N. 31½° W.	10.40	8.87	....	....	5.43	+8.86	−5.44
2	N. 62° E.	9.20	4.32	....	8.13		+4.31	+8.12
3	S. 36° E.	7.60		6.15	4.47		−6.15	+4.46
4	S. 45½° W.	10.		7.01		7.13	−7.02	−7.14
Sum of courses, 37.20			13.19	13.16	12.60	12.56		
			13.16		12.56			
Error in southing...			.03		.04	Error in westing.		

The error in southings, 3 links, is to be distributed among the northings and southings, in proportion to the lengths of the courses; a part to be *added* to the southings, and the remaining part *subtracted* from the northings. The error in westings is similarly distributed among the eastings and westings. For this, two new columns are formed, called, the *balanced* latitudes and departures; and to these columns the latitudes and departures are transferred, after the corrections have been made: the north latitudes being marked +, and the south latitudes −, in order to distinguish them readily, and also, for convenience in the calculations which follow.

The error of .03 in the latitudes is distributed among the latitudes, by subtracting 1 link from each of the northings of courses 1 and 2, and adding 1 link to the southing of course 4. This produces a balance.

Of the error of 4 links in the departures, 1 link is added to each of the departures west, and 1 link subtracted from each of the departures east. This produces a balance.

NOTE.—When a knowledge of the conditions under which the survey was made, enables us to determine that errors were more likely to occur at certain points, it is doubtless best to apply the corrections to those courses where it seems probable the errors were made.

88. The limit of error, to be allowed, depends of course upon the importance of the survey.

In ordinary farming districts, the error should be as small as 1 link to 5 or 10 chains of perimeter.

The "error of the survey" should be considered as the length of the line necessary to *close the boundary*, and is equal to the square root of the sum of the squares of the errors of latitude and departure. Thus, in the above example, the error of the survey is 5 links. The perimeter being 37.20 chains, the error is about 1 link to 7.45 chains, or $\frac{1}{745}$ of the perimeter.

89. It will be well to bear in mind the fact, that if the error in the perimeter has been made in one course only, and distributed by the ordinary methods of balancing, among *all* the courses, the error in area will be larger than the error in perimeter.

90. When the error is so large that a re-survey becomes necessary, the *balancing* should be carefully re-examined.

In many cases, the location of the error may be determined by inspection of the computation, and a portion of the labor of a re-survey, thereby saved.

This refers more particularly to those cases where the error is one of chaining, and is mostly in one course. Errors of this kind occur sometimes with experienced chainmen, who draw the chain properly between the courses, but make occasionally an error in counting the fractional part of a chain at the end of a course.

In such cases, the location of the error may be detected by observing, first what columns contain errors, and secondly the ratio of the errors of Latitude and Departure.

When the error in the survey has been a single one, of distance only, then the ratio between the errors of Latitude and Departure must be the same as the ratio between the Latitude and Departure of the course to be corrected. If the errors be in northings and westings, then the courses running either North and West, or South and East, should be examined.

91. The surveyor should take every possible precaution against errors in the bearings. This is accomplished by back-sighting, taking bearings of some one object from several stations, and also by taking bearings of stations *across* the field. These precautions will give, in general, sufficient data for the detection of an error in *bearing;* for, by mapping the survey, and drawing the lines to indicate the extra bearings, the error is revealed by the failure of the lines to meet at a common point.

92. One source of error, in large surveys with the compass, is frequently overlooked. This is the *diurnal* variation: there is sometimes as much as 15 minutes variation during the daylight hours.

Errors from this source can only be avoided by testing the compass, at intervals of two or three hours, by taking the bearing of the same line.

93. If each of the angles of the survey, included between two consecutive courses, be calculated by the method explained in Article 102, the bearings may then be verified by comparing the sum of these angles with the sum of the interior angles of any polygon (Leg., Bk. I., Prop. 26). The same verification may also be made when the angles are measured with the theodolite or transit.

94. There is one kind of error frequently made in reading the compass when the bearing is nearly east or west. The error arises from reading North for South, or the reverse. If the survey is otherwise correct, the error in latitude is just twice the latitude of the course containing the error.

DOUBLE MERIDIAN DISTANCES.

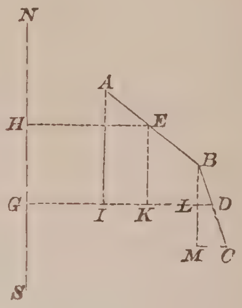
95. After the work has been balanced, the next thing to be done is to calculate the double meridian distance of each course.

For this purpose, any meridian line may be assumed. It is, however, most convenient to assume that meridian which passes through the most easterly or westerly station of the survey; and these two stations are readily determined by inspecting the field-notes.

Having chosen the meridian, let the station through which it passes be called the *principal station*, and the course which begins at this point, *the first course*. *Care, however, must be taken, not to confound this with the course which begins at station* 1, *and which is the first course that is entered in the field-notes.*

It has already been remarked (Art. **71**), that all departures in the direction east are considered as *plus*, and all departures in the direction west as *minus*.

96. To deduce a rule for finding the double meridian distance of any course. Let SN be the assumed meridian. Let BC represent any course, and AB the preceding course; also, let D and E be their middle points. Draw EH, DG, and CM,



perpendicular to the assumed meridian NS. Draw also AI; EK, and BL, parallel to NS. Then $2DG$ is the double meridian distance of the course BC, and $2EH = 2KG$, is the double meridian distance of the course AB.

Now, $2DG = 2GK + 2KL + 2LD$; but $2KL = IL$ is the departure of the course AB, and $2LD = MC$ is the departure of the course BC;

consequently, $$2GD = 2GK + IL + MC;$$

hence, the double meridian distance of a course is equal to the double meridian distance of the preceding course, plus the departure of that course, plus the departure of the course itself: if there is no preceding course, the first two terms become zero. We therefore have the following

RULE.—I. *The double meridian distance of the first course is equal to its departure:*

II. *The double meridian distance of the second course is equal to the double meridian distance of the first course, plus its departure, plus the departure of the second course:*

III. *The double meridian distance of any course is equal to the double meridian distance of the preceding course, plus its departure, plus the departure of the course itself.*

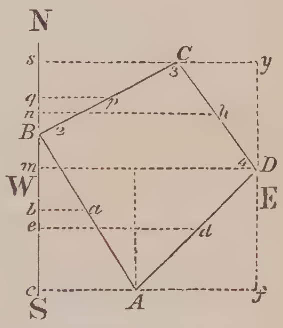
NOTE.—It should be recollected that *plus* is here used in its algebraic sense, and that, when the double meridian distance of a course, and the departure which is to be *added* to it, are of different names, that is, one east and the other west, they will have contrary algebraic signs; hence, their algebraic sum will be expressed by their numerical difference, with the sign of the greater prefixed.

If the assumed meridian cuts the enclosure, the double meridian distances, estimated to the east are plus, and those on the west, must be taken with the *minus* sign.

The double meridian distance of the last course should be equal to the departure of that course. A verification of the work is therefore obtained, by comparing this double meridian distance with that departure.

AREA.

97. Let us resume the example of Art. **75.** We will first write the differences of latitude and the double meridian distances of the courses, in the following table.



Stations.	Dif. of Latitude.	D. M. D.	Area. +	Area. —
1	$+cB$	$+2ba$	$2cAB$	
2*	$+Bs$	$+2qp$	$2BsC$	
3	$-yD$	$+2nh$		$2msCD$
4	$-Df$	$+2ed$		$2cmDA$

It is evident, that cB multiplied by $2ba = cA$, will give double the area of the triangle cAB. But cB and ba are both plus; hence, the product will be plus, and must be put in the column of plus areas. Double the area of the triangle BsC, is equal to Bs multiplied by $2qp$, which product is also plus.

The area of the trapezoid $msCD$ is equal to $yD = ms$ multiplied by nh (Geom., Bk. IV., Prop. VII., .); hence, double the area is equal to yD into $2nh$. But since yD (being a southing) is minus, and $2nh$ plus, it follows that the product will be negative; hence, it must be placed in the column of negative areas.

Double the area of the trapezoid $cADm$, is equal to $Df = mc$ multiplied by $2de$: but, since Df is negative and $2de$ positive, the product will be negative.

It is now evident that the difference between the two columns is equal to twice the contents of the figure $ABCD$: and since the same may be shown for any other figure, we have, for finding the areas, the following general

RULE.—I. *Multiply the double meridian distance of each course by its northing or southing, observing that like signs in the multiplicand and multiplier give plus in the product, and that unlike signs give minus in the product.*

II. *Place all the products which have a plus sign, in one column, and all the products which have a minus sign, in another.*

III. *Add up the columns separately and take the difference of their sums: this difference will be double the area of the land.*

98. We will now make the calculations of this example, in numbers, from the field-notes, which are the following:

Stations.	Bearings.	Distances.	Dif. Lat.	Dep.	D. M. D.
1	N 31½° W	10.40	+8.86	−5.44	+18.02 − 7.14 − 5.44 + 5.44
2*	N 62° E	9.20	+4.31	+8.12	+ 8.12
3	S 36° E	7.60	−6.15	+4.46	+8.12 +4.46 +20.70
4	S 45½° W	10.	−7.02	−7.14	4.46 −7.14 +18.02

We see, from inspecting the notes, that 2 is the most westerly, and 4 the most easterly station. Either of them may, therefore, be taken for the principal station. Let us assume 2 for the principal station, through which the assumed meridian passes, and distinguish it by a star, thus *.

Having done so, we enter the departure 8.12 in the column of double meridian distances, which is the double meridian distance of the course from *B* to *C*. The double meridian distances of the other courses are calculated according to the rule; and as the last, which is that of the course from *A* to *B*, is equal to the departure of that course, the work is known to be right.

Let us now form a new table, which will complete the arithmetical part of the work.

Sta.	Bearings.	Dist.	Dif. Lat.	D. M. D.	Area. +	Area. −
1	N 31½° W	10.40	+8.86	+ 5.44	48.1984	
*2	N 62° E	9.20	+4.31	+ 8.12	34.9972	
3	S 36° E	7.60	−6.15	+20.70		127.3050
4	S 45½° W	10.	−7.02	+18.02		126.5004
					83.1956	253.8054

83.1956

2)170.6098

Area in sq. ch. 85.3049

Dividing by 10 . . . . 8.53049

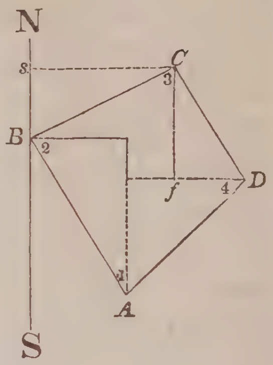
4

2.12196

40

Ans. 8 *A.* 2 *R.* 4.88 *P.* 4.87840

PLOTTING.



99. It now only remains to make a plot of the ground.

For this purpose, draw any line, as NS, to represent the meridian passing through the principal station; and on this line take any point, as *B*, to represent that station.

FIRST METHOD.

Having fixed upon the scale on which the plot is to be made, lay off from *B*, on the meridian, a distance *Bs* equal to the difference of latitude of the second course, and at *s* erect a perpendicular to the meridian, and make it equal to the departure of that course: then draw *BC*, which will be the second course.

Through *C* draw a meridian, and make *Cf* equal to the difference of latitude of the third course, and through *f* draw a perpendicular *fD*, and make it equal to the departure of that course: draw *CD*, and it will be the third course.

Lay down, in the same manner, the courses *DA* and *AB*, and the entire plot will be completed.

SECOND METHOD.

The work may be plotted in another manner, thus. At the principal station *B*, lay off an angle equal to the bearing from *B* to *C*, which will give the direction of *BC*. Then, from the scale of equal parts, make *BC* equal to the second course: this will give the station *C*.

Through *C* draw a meridian, and lay off an angle equal to the bearing from *C* to *D*, and then lay off the course *CD*. Do the same for the bearing at *D* and the course *DA*; also, for the bearing at *A* and the course *AB*, and a complete plot of the ground will thus be obtained. If the work is all right, the first line *AB*, that was run, and the last line plotted, will exactly close the figure. This plot is made on a scale of 10 chains to an inch.

BY TABLE OF NATURAL SINES.

100. If the land surveyed be very valuable, and very great accuracy is necessary in the computation of the area, it may be well to calculate it by means of the Table of Natural Sines (Bk. I., Art. 57).

In this Table the degrees are marked at the top and bottom of each page, and the minutes at the left and right. The table being calculated to the radius 1, the sines and cosines are expressed in decimals of 1. When the Table is used for the computation of areas, the cosines are the differences of latitude, and the sines the differences of departure, to the distance 1. Hence, if the cosine and sine be taken from the table, for any course, and then multiplied respectively by the length of the course, the products will be the latitudes and departures for that course and distance.

Let us resume the last example.

Stations.	Bearings.	Distances.	LATITUDE.		DEPARTURE.	
			N +	S —	E +	W —
1	N $31\frac{1}{2}$° W	10.40	8.8675			5.4340
2	N 62° E	9.20	4.3191		8.1231	
3	S 36° E	7.60		6.1486	4.4672	
4	S $45\frac{1}{2}$° W	10.		7.0091		7.1325

We first take from the Table of Natural Sines, page 69 (of Tables), the cosine and sine of $31\frac{1}{2}$°, which are .85264 and .5225.

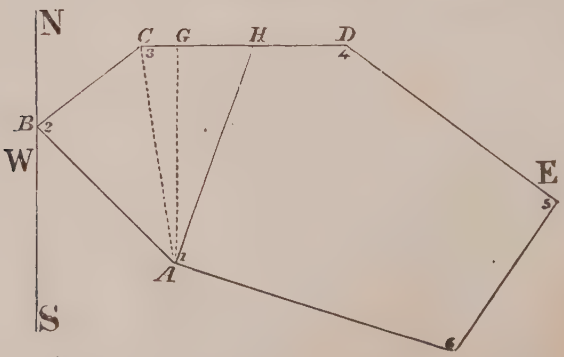
We then multiply them by the distance 10.40, and the products 8.867456 and 5.43400 are the latitudes and departures of the course; which we enter in the table, omitting the decimals after the fourth place. We find, in a similar manner, the latitudes and departures of the other courses; after which the work is balanced and wrought, as with the Traverse Table.

EXAMPLES.

1. It is required to determine the contents and plot of a piece of land, of which the following are the field-notes—viz.:

Stations.	Bearings.	Dist.	Dif. Lat.		Dep.		BALANCED.		D.M.D.	AREA.	AREA.
			N +	S —	E +	W —	Lat.	Dep.	+	+	—
1	N 46½° W	20.76	14.29			15.06	+14.30	—15.04	15.04	215.0720	
2	N 51¾° E	13.80	8.54		10.84		+8.55	+10.86	10.86	92.8530	
3	E	21.35			21.35			+21.37	43.09		
4	S 56° E	27.60		15.44	22.88		—15.43	+22.90	87.36		1347.9648
5	S 33¼° W	18.80		15.72		10.31	—15.71	—10.29	99.97		1570.5287
6	N 74½° W	30.95	8.27			29.83	+8.29	—29.80	59.88	496.4062	
			31.10	31.16	55.07	55.20				804.3312	2918.4935
				31.10		55.07					804.3312
			Error....	.06		.13	Error.				2)2114.1623
								Ans. 105 *A.* 2 *R.* 33 *P.*			1057.08115

Plot of the ground.



NOTE.—When the bearing is due East or due West, the error in latitude is nothing, and the corrections for latitude must be distributed among the other courses. So, when the bearing is due North or due South, the error in departure is nothing, and the error in departure must be distributed among the other courses. In the examples for practice, we have not been as careful to have as close balances as must be had, in actual work on the field.

2. Required the contents and plot of a piece of land, of which the following are the field-notes.

Stations.	Bearings.	Distances.
1	S 34° W	3.95 ch.
2	S	4.60
3	S 36½° E	8.14
4	N 59½° E	3.72
5	N 25° E	6.24
6	N 16° W	3.50
7	N 65° W	8.20

Ans. 10 *A.* 0 *R.* 5 *P.*

3. Required the contents and plot of a piece of land, from the following field-notes.

Stations.	Bearings.	Distances.
1	S 40° W	70 rods.
2	N 45° W	89
3	N 36° E	125
4	N	54
5	S 81° E	186
6	S 8° W	137
7	W	130

Ans. 207 *A.* 3 *R.* 33 *P.*

4. Required the contents and plot of a piece of land, from the following notes.

Stations.	Bearings.	Distances.
1	S $40\frac{1}{2}$° E	31.80 ch.
2	N 54° E	2.08
3	N $29\frac{1}{4}$° E	2.21
4	N $28\frac{3}{4}$° E	35.35
5	N 57° W	21.10
6	S 47° W	31.30

Ans. 92 *A.* 3 *R.* 32 *P.*

5. Required the area of a survey, of which the following are the field-notes.

Stations.	Bearings.	Distances.
1	N 42° E	5.00 ch.
2	East.	4.00
3	N 9° E	4.00
4	S 69° E	5.56
5	S 36° E	7.00
6	S 42° W	4.00
7	S 75° W	10.00
8	S 39° W	7.50

If, in this example, we assume 1 as the principal station, the double meridian distances will all be plus, and the positive area will exceed the negative.

In balancing, we shall find the error in southing to be .28 ch., and in westing .22 ch. The area is 13 *A.* 0 *R.* 11 *P.* It should, however, be remarked, that in all the examples the answers may be slightly varied by distributing the corrections.

6. What is the area of a survey of which the following are the field-notes? Make the plot.

Stations.	Bearings.	Distances.
1	N 75° 00′ E	54.8 rods.
2	N 20° 30′ E	41.2
3	East.	64.8
4	S 33° 30′ W	141.2
5	S 76° 00′ W	64.0
6	North.	36.0
7	S 84° 00′ W	46.4
8	N 53° 15′ W	46.4
9	N 36° 45′ E	76.8
10	N 22° 30′ E	56.0
11	S 76° 45′ E	48.0
12	S 15° 00′ W	43.4
13	S 16° 45′ W	40.5

In this survey 4 is the most easterly and 9 the most westerly station. The area is equal to 110 *A.* 2 *R.* 23 *P.* It may vary a little, on account of the way in which the balancing is done.

7. What is the area of a survey of which the following are the notes? Make the plot.

Stations.	Bearings.	Distances.
1	S 46½° E	80 rods.
2	S 51¾° W	55.20
3	West.	85
4	N 56° W	110.40
5	N 33¼° E	75.20
6	S 74½° E	123.80

Ans. 104 *A.* 1 *R.* 16 *P.*

8. Required the area of the farm, of which the survey notes are given on page 117.

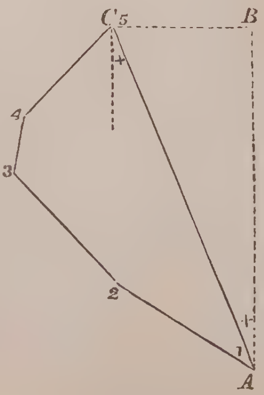
Stations.	Bearings.	Distances.
A	N 68° 55′ W	31.95
B	N 8° E	1.40
C	S 87° 05′ W	22.89
D	N 30° 35′ E	8.39
E	N 42° 05′ E	23.91
F	N 87° 05′ E	14.51
G	S 64° 30′ E	7.55
H	S 71° E	12.21
I	S 27° E	17.39
K	S 30° W	16.97

Offsets between C and D to be added, 15.9450 chains.

Offsets to be subtracted, 15.1885 chains.

PROBLEMS.

I. To determine the bearing and distance from one point to another, when they are so situated that one cannot be seen from the other.



101. Let *A* and *C* be the two points, and *AB* a meridian passing through one of them. From either of them, as *A*, measure a course *A* 2, of a convenient length in the direction toward *C*, and take the bearing with the compass. At 2, take the bearing of a second course, and measure the distance to 3. At 3, take a third bearing and measure to 4. At 4, take the bearing to *C*, and measure the distance from 4 to *C*.

Then, the difference between the sum of the northings and the sum of the southings will be denoted by AB; and the difference between the sum of the eastings and the sum of the westings, by BC. The base AB, and the perpendicular BC of the right-angled triangle ABC, are then known. The angle at the base, BAC, is the bearing from A to C; or the equal alternate angle at C is the bearing from C to A, and the hypothenuse AC, is the distance.

Having measured the bearings and courses on the field, form a table, and find the base and perpendicular of the right-angled triangle, in numbers; after which, find the bearing and distance.

Stations.	Bearings.	Distances.	N.	S.	E.	W.
1	N 61° W	40 ch.	19.39			34.98
2	N 42° W	41.	30.47			27.43
3	N 12° E	16.10	15.75		3.35	
4	N 47° E	32.50	22.16		23.77	
			$AB = 87.77$		27.12	62.41
						27.12
						$CB = 35.29$ ch.

To find the angle BAC, or the bearing from A to C.

$$\text{Radius} : \tan A :: AB : BC,$$

$$\text{or,} \quad AB : BC :: R : \tan A;$$

that is, applying logarithms,

(a. c.) log AB (87.77) 8.056654
log BC (35.29) 1.547652
log R . . . . 10.
log tan A 21° 54′ 12″ 9.604306

To find the distance AC.

$$\sin A : R :: BC : AC;$$

Applying logarithms,

(a. c.) log sin A 21° 54′ 12 . . . . 0.428242
log R . . . . 10.
log BC (35.29) 1.547652
log AC 94.6 . . . . 1.975894

Hence, the bearing and distance are both found.

NOTE 1.—Had any of the courses run south, AB would have been equal to the sum of the northings, minus the sum of the southings.

NOTE 2.—The last problem affords an easy method of finding the bearing and length of one of the courses of a survey, when the bearings and lengths of all the others are known. It may be necessary to use this method when there are obstacles which prevent the measuring of a course, or when the bearing cannot be taken. Indeed, *two omissions* may in general be supplied by calculation. It is far better, however, if possible, to take all the notes on the field. For, when any of them are supplied by calculation, there are no tests by which the accuracy of the work can be ascertained, and all the errors of the notes effect also the parts which are supplied.

EXAMPLES.

1. In a survey we have the following notes:

Stations.	Bearings.	Distances.
1	N $31\frac{1}{2}$° W	10 ch.
2	N $62\frac{3}{4}$° E	9.25
3	Lost.	Lost.
4	S $45\frac{1}{2}$° W	10.40

What is the bearing distance from station 3 to 4?

Ans. { Bearing, S 38° 52′ E.
Distance, 7.03 ch.

2. In a survey we have the following notes:

Stations.	Bearings.	Distances.
1	S 40½° E	31.80 ch.
2	N 54° E	2.08
3	Lost.	Lost.
4	N 28¾° E	35.35
5	N 57° W	21.10
6	S 47° W	31.30

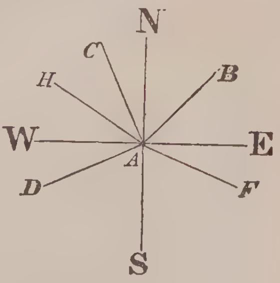
What is the bearing and distance from 3 to 4?

Ans. { Bearing, N 34° 47′ E.
Distance, 2.19 ch.

II. To determine the angle included between any two courses, when their bearings are known.

102. Let NS be a meridian passing through *A*.

Let *AB*, *AC*, *AH*, *AD*, and *AF*, be five courses running from *A*. We readily deduce the following



PRINCIPLES.

AC is N 26° W
AH is N 65° W
CAH = 39°

When the meridional letters are alike, and those of departure also alike, *the difference of the bearings is the angle between the courses.*

AB is N 46° E
AC is N 26° W
$CAB = 72°$

When the meridional letters are alike, and those of departure unlike, *the sum of the bearings is the angle between the courses.*

AC is N 26° W
AD is S 66° W
$CAD = 180° - 92° = 88°$

When the meridional letters are unlike, and those of departure alike, *the angle between the courses is equal to* 180°, *minus the sum of the bearings.*

AC is N 26° W
AF is S 66° E
$CAF = 180° - 40° = 140°$

When the meridional letters are unlike, and those of departure also unlike, *the angle between the courses is equal to the difference of the bearings taken from* 180°.

NOTE.—The above principles are deduced, under the supposition that the two courses are both run from the same angular point. Hence, if it be required to apply these rules to two courses run in the ordinary way, as we go around the field, the bearing of one of them must be *reversed* before the calculation for the angle is made.

EXAMPLES.

1. The bearings of two courses, from the same point, are N 37° E, and S 85° W: what is the angle included between them? *Ans.* 132°.

2. The bearings of two adjacent courses, in going round a piece of land, are N 39° W, and S 48° W: what is the angle included between them? *Ans.* 87°.

3. The bearings of two adjacent courses, in going round a piece of land, are S 85° W, and N 69° W: what is the angle included between them? *Ans.* 154°.

4. The bearings of two adjacent courses, in going round a piece of land, are N 55° 30′ E, and S 69° 20′ E: what is the angle included between them? *Ans.* 124° 50′.

Laying out and dividing Land.

103. The surveyor is often required to lay off a given quantity of land, in such a way that its bounding lines shall form a particular figure, viz., a square, a rectangle, a triangle, &c. He is also often called upon to divide given pieces of land into parts containing given areas, or, into areas bearing certain relations to each other.

The manner of making such divisions must always depend on a skilful and judicious application of the principles of geometry and trigonometry to the particular case.

For example, if it were required to lay out an acre of ground, in a square form, it would be necessary to find, by calculation, the side of such a square, and then trace, on the ground, a figure bounded by four equal sides, at right angles to each other.

PROBLEM I.

104. **To lay out a given quantity of land in a square form.**

Rule.—*Reduce the given area to square chains, or square rods: then extract the square root, and the result will be the side of the required square. This square being described on the ground, will be the figure required.*

1. To trace a square which shall contain $15\,A.\ 0\,R.\ 12\,P.$

First, $15\,A = 60\,R = 2400\,P$; hence,

Add, $\underline{12\,P}$

$15\,A\ 0\,R\ 12P = 2412\,P$; the square root of which is 49.11, nearly. Therefore, if a square be traced on the ground, of which the side is 49.11 rods, it will be the required figure.

2. To trace a square which shall contain 176 A. 1 R. 24 P.

First, $176\,A = 1760$ square chains,
$1\,R = 2.5$ " "
hence, $24\,P = 1.5$ " "

$176\,A\ 1\,R = 24\,P = 1764$ square chains: the square root of which is 42. Hence, if a square be traced on the ground, of which the side is 42 chains, it will be the required figure.

PROBLEM II.

105. **To lay out a given quantity of land in a rectangular form, when one of the sides of the rectangle is given.**

RULE.—*Divide the given area, reduced to square chains or square rods, by the given side of the required rectangle, and the quotient will be the other side. Then, trace the rectangle on the ground.*

1. To lay off 240 acres in a rectangular form, one of the sides being given, and equal to 80 rods.

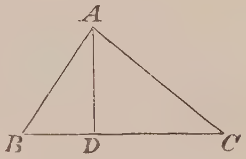
First, $240\,A = 2400$ square chains $= 38400$ square rods.

Then, 80)38400(480 rods; which is the required side of the rectangle.

NOTE.—A great number of similar problems might be proposed. The solution of them does not, however, properly belong to surveying. The laying out of the ground, and tracing of lines, after the figure and area have been determined, are the only parts which really appertain to a practical treatise. The manner of tracing lines having been already explained, it seems unnecessary to add the numerous examples often given under this head of the subject.

PROBLEM III.

106. **To run a line from the vertex of a triangular field which shall divide it into two parts, having to each other the ratio of m to n.**



Let ABC be any triangular field.

Divide the side BC into two parts, such that (Geom., Bk. IV., Prob. I.)

$$BD : DC :: m : n;$$

and draw the line AD:

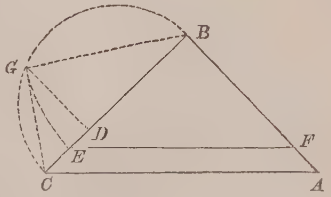
then will, $ABD : DAC :: m : n$.

For, the two triangles ABD, ADC having the same altitude, are to each other as their bases (Geom., Bk. IV., P. 6, C.): hence, the triangle is divided into parts having the ratio of m to n.

PROBLEM IV.

107. **To run a line parallel to one side of a triangular field, that shall form with the parts of the two other sides a triangle equal to the $\frac{m}{n}$ part of the field.**

Let CBA represent a triangular field, and CA the side parallel to which the dividing line is to be drawn.



On the side BC describe a semicircle: then divide BC at D, so that

$$BD : BC :: m : n.$$

At D, erect the perpendicular DG to the diameter BC, and draw BG. Then, with B as a centre, and BG as a radius, describe the arc of a circle cutting BC at E. Through E draw EF parallel to CA, and it will divide the triangle in the required ratio. For, (Geom., Bk. IV., P. 23),

$\overline{BG}^2 = \overline{BE}^2 = BC \times BD$; or, $\overline{BE}^2 = \overline{BC}^2 \times \dfrac{BD}{BC}$; whence,

$$\overline{BE}^2 : \overline{BC}^2 :: BD : BC : m : n.$$

But, since the triangles BEF, BCA are similar,

$$\overline{BE}^2 : \overline{BC}^2 :: BEF : BCA.$$

Wherefore, from equality of ratios,

$$BEF : BCA :: m : n;$$

whence, $$BEF = \frac{m}{n} \times BCA.$$

NOTE 1.—The points E and F may easily be found by computation.

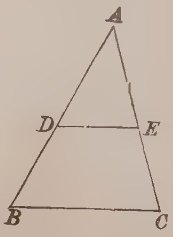
For, since $\overline{BE}^2 = \overline{BG}^2 = BC \times BD$, and $BD = \dfrac{m}{n} \times BC$,

we have, $\overline{BE}^2 = \overline{BC}^2 \times \dfrac{m}{n}$; or, $BE = BC\sqrt{\dfrac{m}{n}}$.

In like manner, $$BF = BA\sqrt{\frac{m}{n}}.$$

EXAMPLE.

Let it be required to divide the triangular field CAB, in which $AC = 9$ ch., $AB = 11$ ch., and $CB = 7$ ch., into two such parts that ABE shall be one-fourth of the whole field.



In this case, we have,

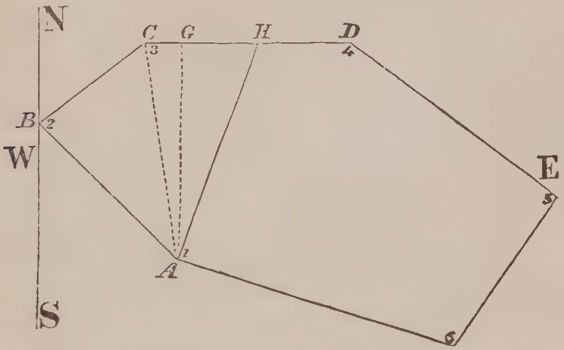
$m = 1$, $n = 4$ and $\sqrt{\dfrac{m}{n}} = \sqrt{\dfrac{1}{4}} = \dfrac{1}{2}$:

hence, $AE = 4$ ch. 50 l., and $AD = 5$ ch. 50 l.

PROBLEM V.

108. **To run a line from a given point in the boundary of a piece of land, so as to cut off, on either side of the line, a given portion of the field.**

Make a complete survey of the field, by the rules already given. Let us take, as an example, the field whose area is computed at page 136. That field contains 105 *A.* 2 *R.* 33 *P.*, and the following is a plot of it.



Let it now be required to run a line from station *A*, in such a manner as to cut off, on the left, any part of the field; say, 26 *A* 2 *R* 31 *P.*

It is seen, by examining the field, that the division line will probably terminate on the course *CD.* Therefore, draw a line from *A* to *C*, which we will call the *first closing line.*

The bearings and lengths of the courses *AB*, *BC*, are always known; and in the present example are found in the table on page 136: hence, the bearing and distance from *C* to *A* can be calculated by Art. **101**: they are, in this example,

Bearing, S 9° 28′ E: Course, 23.22 ch.

Having calculated the bearing and length of the closing line, find, by the general method, the area which it cuts off: that area, in the present case, is

14 *A* 0 *R* 26 *P.*

It is now evident that the division line must fall on the right of the closing line *AC*, and must cut off an area *ACH*, equal to the difference between that already cut off, and the given area: that is, an area equal

26 *A* 2 *R* 31 *P* given area,
14 *A* 0 *R* 26 *P* area already cut off,

to . . . . 12 *A* 2 *R* 5 *P*.

Since the bearing of the next course *CD*, and the bearing of the closing line *AC* are both known, the angle *ACD* which they form with each other, can be calculated, and is in this example, 79° 32′. Hence, knowing the hypothenuse *AC*, and the angle *ACG* at the base, the length *AG*, the perpendicular let fall on the course *CD* can be found, and is 22.82 chains.

Since the area of a triangle is equal to its base multiplied by half its altitude, it follows, that the base is equal to the area divided by half the altitude. Therefore, if the area

12 *A* 2 *R* 5 *P*

be reduced to square chains, and divided by 11.41 chains, which is half the perpendicular *AG*, the quotient, which is 10.95 chains, will be the base *CH*. Hence, if we lay off from *C*, on *CD*, a distance *CH*, equal to 10.95 chains, and then run the line *AH*, it will cut off, from the land, the required area, viz.,

26 *A* 2 *R* 31 *P*.

NOTE 1.—If the part cut off by the first closing line should exceed the given area, the division line will fall on the left of *AC*.

NOTE 2.—If the difference between the given area and the first area cut off, divided by half the perpendicular *AG*, gives a quotient larger than the course *CD*; then, draw a line from *A* to *D*, and consider it as the first closing line, and let fall a perpendicular on *DE*.

NOTE 3.—When the point from which the division line is to be drawn falls between the extremities of a course, divide the course into two parts, at this point. Then consider one of the parts as an entire course, and the other as forming a new course, having the same bearing. The manner of making the calculation will then be the same as before.

PROBLEM VI.

109. To cut off from a field, a given area, by a line running in a given direction.

In this case, as in the previous one, a complete and correct survey is first necessary. Then, when the whole area is known, the position of the line may be approximately determined by the inspection of a correct map of the whole.

We will take, for illustration, Example 4, page 138, of which the plot is on the next page.

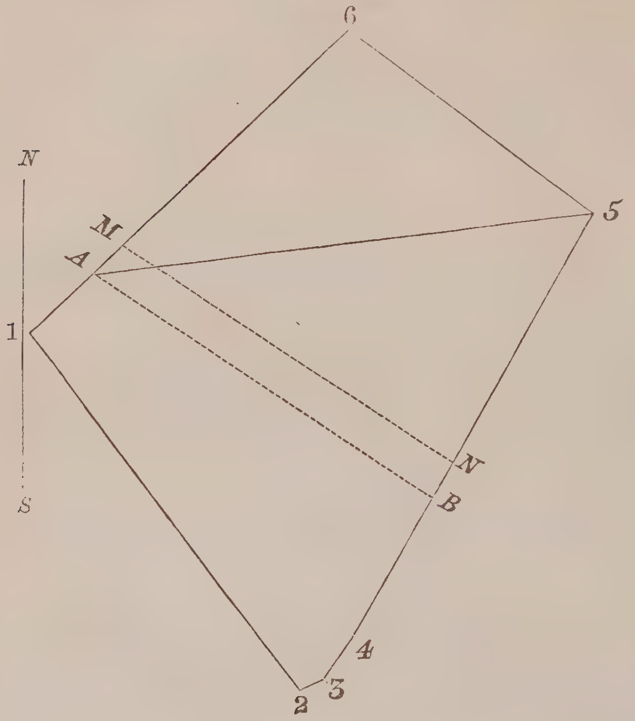
Let it be required to cut off from this area, 50 acres, by a line whose bearing shall be S 60° E, or N 60° W.

We will make a trial of a line starting at 25 chains from station 6, on the 6th course. We will call this station *A*, and the trial line *AB*.

In order to determine if the area cut off is equal to the required area, we must first determine the length of *AB* and of *B* 5. These cannot be determined by the method of supplying lost notes.

We must first calculate the length of a line, starting at the proposed point, and running to the station nearest to the other extremity of the closing line. In this example, from *A* to 5. This is easily found to be 36.406 chains, and its bearing N 81° 13′ E.

Now, in the triangle $AB5$ we have one side and the angles, to find the remaining parts. AB is found to be 28.88 chains and $B5$ to be 22.81 chains. We have now the complete field-notes of the area cut off.



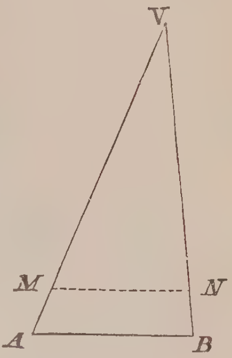
A	S 60° E	28.88 ch.
B	N $28\frac{3}{4}$° E	22.81
5	N 57° W	21.10
6	S 47° W	25.00

The area is found to be 58.5029 acres.

It now remains to move this line northerly, so that the area contained between its present position and the new one shall be equal to 8.5029 acres.

Suppose the lines *A* 6 and *B* 5 be prolonged till they meet at some point, as *V*.

Calculate *A V* and *B V*, also the area *ABV*. *A V* is found to be 92.19 chains and *B V* 88.18 chains. The area of the triangle *ABV*, is 127.29 acres. Let *MN* represent the line sought. Then, we have two similar triangles, with all the sides of the one, and the areas of each, known; for, *VMN* must contain 8.5029 acres less than *AVB*. Then, *AM* and *BN* are easily determined.



The complete notes of the area to be cut off, are

M	S 60° E	27.89
N	N 28¾° E	19.82
5	N 57° W	21.10
6	S 47° W	21.87

NOTE.—Fields are so variously shaped that it is difficult to give rules that will apply to all cases. It is by practice alone that facility is obtained in that branch of surveying relating to the division of estates. We have given only a few examples that may serve as general guides, in the application of the principles of Plane Geometry, to such cases as may arise.

PUBLIC LANDS.

110. Soon after the organization of the present government, several of the States ceded to the United States large tracts of wild land, and these, together with the lands since acquired by treaty and purchase, constitute what is called the public lands, or public domain. Previous to the year 1802, these lands were parcelled out without reference to any general plan, in consequence of which the titles often conflicted with each other, and in many cases, several grants covered the same area.

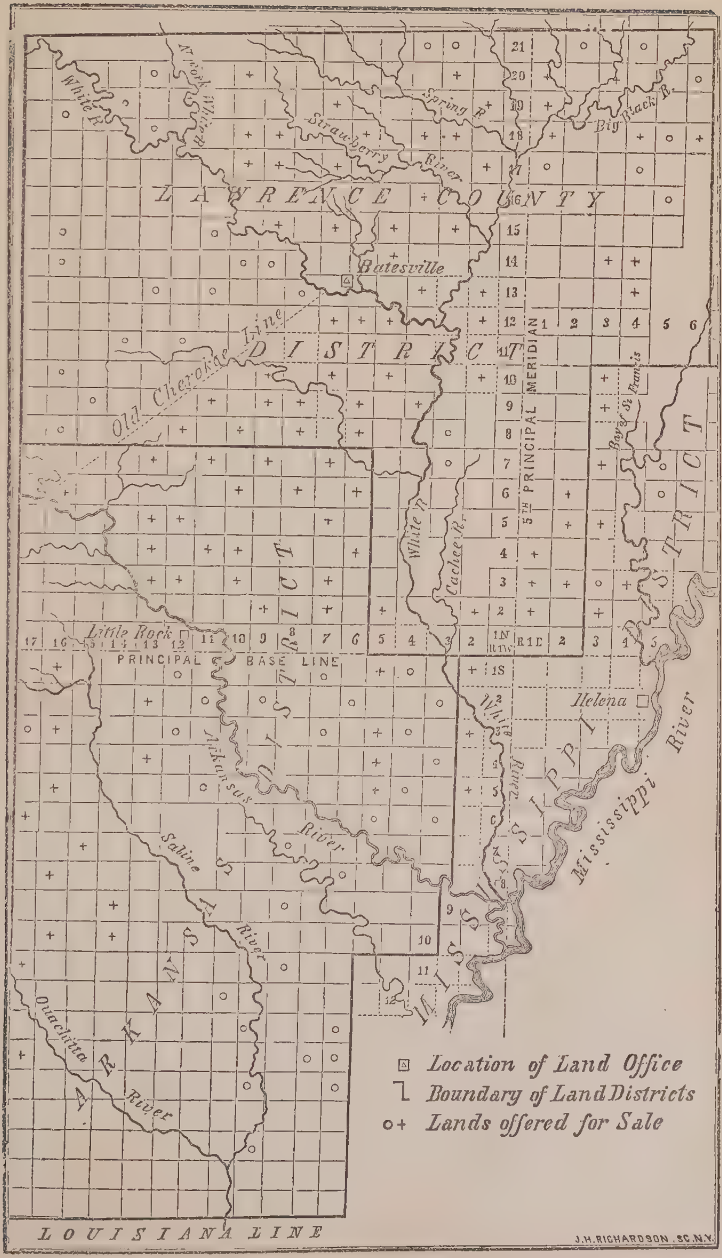
In the year 1802, the following method of surveying the public lands, was adopted by Colonel Jared Mansfield, then Surveyor-General of the Northwestern Territory.

111. The country to be surveyed is first divided, by meridians, six miles distant from each other; and then again, by a system of east and west lines, also six miles from each other. The country is thus divided into equal squares, which are called *townships*. Hence, each township is a square, six miles on a side, and contains thirty-six square miles.

112. For the purpose of illustration, we have obtained from the general land-office the accompanying map, which represents a considerable portion of the State of Arkansas.

The principal meridian in this survey is called the 5th meridian, and passes through the point of junction of the White river with the Mississippi. The principal base-line, running east and west, intersects this meridian a little to the east of White river; and from the meridian and base-line, reckoned from this point of intersection, all the ranges of townships are laid off.

For example, 1 North, will apply to all the townships lying in the first row north of the base-line: 1 South, will apply to all the townships in the first row south of the base-line. Range 1 East, will apply to all the townships lying in the first row, east of the 5th meridian: and Range 1 West, will apply to all lying in the first row to the west of it. The small figures designate the rows of townships, reckoned north and south from the base-line, and the ranges reckoned east and west from the 5th meri-


LAWRENCE COUNTY
DISTRICT
White R.
N. Fork White R.
Strawberry River
Spring R.
Big Black R.
Batesville
Old Cherokee Line
5TH PRINCIPAL MERIDIAN
White R.
Cachee R.
Bayou St. Francis
DISTRICT
Little Rock
PRINCIPAL BASE LINE
Arkansas River
Saline R.
Helena
White River
Mississippi River
MISSISSIPPI DISTRICT
ARKANSAS DISTRICT
Ouachita River
LOUISIANA LINE
Location of Land Office
Boundary of Land Districts
Lands offered for Sale
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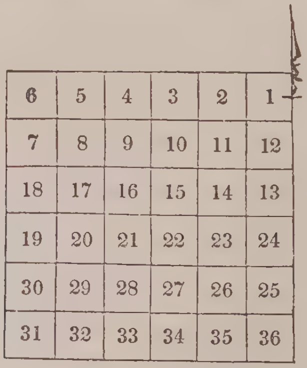
dian. Thus, township 1 North, range 4 West, has its exact place designated, and may be immediately located.

113. The principal meridians, and the principal base-lines are established by astronomical observation, and the lines of subdivision run with the compass.

For convenience in making surveys, and for the purpose of designating particular localities, a state or large tract, is often divided into parts called "Districts." There are three such districts in the map before us, the Lawrence County District, the Arkansas District, and the Mississippi District, the boundaries of which are designated by the full dark lines.

114. Each township is divided into equal squares, by meridians one mile apart, and by east and west lines at the same distance from each other. Hence, each township is divided into 36 square miles, each one of which is called a *section*. The sections of a township are numbered from 1 to 36, beginning at the northeast angle, and each contains 640 acres.

The diagram exhibits the 36 sections of a township.



6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

To describe a section accurately, we say, section number 5, in township number 4 north, in range 3d west of a known meridian; the one, for example, drawn through the mouth of White river. The description fixes precisely the place of the section. Go to the 3d range of townships, west of the known meridian, find township number 4 north, in this range, and lastly, section number 5 of that township. The corners of the sections should be marked by permanent corner-posts, or by lines blazed on trees.

115. The sections are divided into half sections, quarter sections, and even into eighths of sections. The following table shows the contents of a township, and its subdivisions:

1 township = 36 sections = 23040 acres.
1 section = 640 acres.
$\frac{1}{2}$ section = 320 acres.
$\frac{1}{4}$ section = 160 acres.
$\frac{1}{8}$ section = 80 acres.

VARIATION OF THE NEEDLE.

116. The angle which the magnetic meridian makes with the true meridian, at any place on the surface of the earth, is called the *variation of the needle* at that place.

The variation is east, when the northern end of the needle, after settling to a state of rest, lies on the east of the true meridian; and west, when it lies on the west side of that meridian.

117. The variation is different at different places, and even at the same place it does not remain constant for any length of time. The variation is ascertained by comparing the magnetic with the true meridian.

118. If we suppose a line to be traced through those points, where the needle points directly north and south, such a line is called the *line of no variation.*

By referring to a map of the United States, such line is easily traced; for, in the year 1870, it passed, very nearly, through Raleigh, in the State of North Carolina, Cleveland, in the State of Ohio, and crossed the Saut of St. Mary's at the lower end of Lake Superior. If a compass, at that time, had been placed anywhere on this line, the needle would have pointed due north and south: hence, this line was then the line of *no variation.*

At all points on the surface of the earth, the north end of the needle inclines toward the *line of no variation:* hence, for all points east of this line, the variation is *West;* and for all points west of it, the variation is *East.*

Places where the Variation is West.

West. +	Latitude.	Longitude	Nearest Place.	Latitude.	Longitude	Nearest Place.
0°	35° 00′	78° 10′	Raleigh ±	41° 30′	81° 45′	Cleveland ±
1°	36° 00′	77° 20′	Plymouth +	40° 30′	80° 00′	Pittsburgh –
2°	37° 00′	76° 25′	Richmond –	42° 00′	80° 10′	Erie –
3°	39° 00′	76° 40′	Anapolis –	40° 40′	78° 00′	Harrisburgh –
4°	40° 00′	76° 25′	Harrisburgh –	43° 20′	79° 00′	Buffalo ±
5°	40° 00′	75° 25′	Wilmington –	43° 00′	78° 00′	Buffalo –
6°	40° 00′	74° 10′	Trenton –	43° 00′	77° 10′	Oswego +
7°	41° 00′	74° 00′	New York –	43° 00′	76° 00′	Oswego ±
8°	41° 20′	73° 00′	New Haven +	44° 00′	76° 00′	Oswego –
9°	42° 10′	73° 00′	Hartford –	43° 00′	74° 00′	Albany –
10°	42° 00′	71° 35′	Providence ±	44° 00′	74° 00′	
11°	42° 00′	70° 25′	Boston –	44° 00′	73° 00′	Montpelier ±
12°	44° 00′	72° 00′	Montpelier ±	45° 40′	74° 00′	Montreal +
13°	44° 00′	71° 00′	Portland +	46° 00′	73° 30′	Montreal +
14°	44° 10′	70° 00′	Portland –	46° 20′	73° 00′	
15°	44° 20′	69° 00′	Augusta –	46° 20′	72° 00′	
16°	45° 00′	69° 00′		47° 00′	72° 00′	Quebec +
17°	45° 00′	68° 00′		47° 00′	71° 00′	Quebec +
18°	45° 00′	67° 00′	St. Andrews	47° 00′	70° 00′	

119. The table on the last page, and the one which follows, on the next, have been constructed from the magnetic chart accompanying the Annual Report of the Coast Survey of 1865, and all the magnectic meridians are calculated for the year 1870.

On that chart, we find the meridian of no variation. It passes through Raleigh, in the state of North Carolina (very nearly), and through Cleveland, in the state of Ohio. East of it, is marked the magnetic meridian of one degree: that is, the magnetic meridian, at any point of which, the variation is 1 degree west. Two points of this meridian are noted in the table: viz., the point whose latitude is 36° north, and longitude 77° 20′ west; and also the point whose latitude is 40° 30′, and longitude 80°. Marking these two points, on a map of the United States, the magnetic meridian of one degree variation, west, may be drawn. And in a similar manner any magnetic meridian (of which two points are indicated by the table), may be drawn.

To aid in the ready selection of any point, indicated in the table, the prominent place, *nearest* to it, is written in the adjoining column; and when the place lies *east* of the point (and consequently the point *west* of the place), the sign + is annexed; and the sign −, when the place lies west of the point, and the sign ±, when the meridian passes through, or very near the place. Thus, in the meridian of 1° variation, Plymouth, in North Carolina, is east of the first point, and Pittsburgh, west of the second.

Places where the Variation is East.

East.	Latitude.	Longitude.	Name of Place.	Latitude.	Longitude.	Name of Place.
0°	35° 00′	78° 10′	Raleigh	41° 30′	81° 45′	Cleveland
1°	34° 00′	79° 10′	Wilmington +	41° 00′	88° 00′	Detroit ±
2°	33° 00′	80° 10′	Charleston ±	43° 00′	84° 30′	Lansing —
4°	33° 00′	86° 30′	Milledgeville +	40° 00′	85° 30′	Indianapolis —
6°	31° 00′	87° 00′	Mobile —	42° 00′	88° 10′	Chicago +
7°	30° 00′	89° 20′	New Orleans —	43° 00′	89° 25′	Madison, In. ±
9°	29° 00′	95° 00′	Galveston +	38° 00′	91° 20′	St. Louis +
13°	32° 00′	115° 00′	San Diego —	36° 00′	104° 00′	Santa Fe —
16°	37° 15′	122° 00′	San Francisco —	40° 20′	112° 00′	Salt Lake City —
21°	46° 00′	124° 00′	Astoria +			

This table is interpreted like the preceding. At San Diego, on the Pacific, the variation is 13° 25′ East; at San Francisco, it is 16° 30′; and at the mouth of the Columbia river, it is 21° 10′ East.

METHODS OF ASCERTAINING THE VARIATION.

120. The best practical method of determining the true meridian of a place, is by observing the north star. If this star were precisely at the point in which the axis of the earth, prolonged, pierces the heavens, then, the intersection of the vertical plane passing through it and the place, with the surface of the earth, would be the true meridian. But, the star being at a distance from the pole, equal to 1° 30′ nearly, it performs a revolution about the pole in a circle, the polar distance of which is 1° 30′, nearly.

To the eye of an observer, this star is continually in motion, and is due north but twice in 24 hours; and is then said to be on the meridian. Now, when it departs from the meridian, it apparently moves east or west, for 12 hours, and then returns to the meridian again. When at its greatest distance from the meridian, east or west, it is said to be at its greatest *eastern* or *western* elongation.

The following tables show the times of its greatest eastern and western elongations:

EASTERN ELONGATIONS.

Days.	April.	May.	June.	July.	August.	Sept.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	18 32	16 35	14 33	12 35	10 34	8 32
7	18 09	16 11	14 09	12 12	10 10	8 09
13	17 45	15 47	13 46	11 48	9 47	7 45
19	17 22	15 24	13 22	11 25	9 23	7 22
25	16 58	15 00	12 59	11 01	9 00	6 58

WESTERN ELONGATIONS.

Days.	October.	Nov.	Dec.	Jan.	Feb.	March.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	18 24	16 22	14 24	12 21	10 18	8 28
7	18 01	15 59	14 00	11 57	9 55	8 04
13	17 37	15 35	13 37	11 33	9 31	7 41
19	17 13	15 11	13 13	11 10	9 07	7 17
25	16 50	14 48	12 49	10 46	8 44	6 53

The eastern elongations are put down from the first of April to the first of October; and the western, from the first of October to the first of April: the time is computed from 12 at noon. The western elongations in the first case, and the eastern in the second, occurring in the daytime, cannot be used. Some of those put down are also invisible, occurring in the evening, before it is dark, or after daylight in the morning. In such case, if it be necessary to determine the meridian at that particular season of the year, let 6 hours be added to, or subtracted from, the time of greatest eastern or western elongation, and the observation be made at night, when the star is on the meridian.

AZIMUTH TABLE.

YEARS.	Lat. 32° Azimuth.	Lat. 34° Azimuth.	Lat. 36° Azimuth.	Lat. 38° Azimuth.	Lat. 40° Azimuth.	Lat. 42° Azimuth.	Lat. 44° Azimuth.
1870	$1^\circ\ 37\frac{3}{4}'$	$1^\circ\ 40'$	$1^\circ\ 42\frac{1}{2}'$	$1^\circ\ 45\frac{1}{4}'$	$1^\circ\ 48\frac{1}{4}'$	$1^\circ\ 51\frac{1}{2}'$	$1^\circ\ 55\frac{1}{4}'$
1871	$1^\circ\ 37\frac{1}{4}'$	$1^\circ\ 39\frac{1}{2}'$	$1^\circ\ 42'$	$1^\circ\ 44\frac{3}{4}'$	$1^\circ\ 47\frac{3}{4}'$	$1^\circ\ 51'$	$1^\circ\ 54\frac{3}{4}'$
1872	$1^\circ\ 37'$	$1^\circ\ 39\frac{1}{4}'$	$1^\circ\ 41\frac{3}{4}'$	$1^\circ\ 44\frac{1}{4}'$	$1^\circ\ 47\frac{1}{4}'$	$1^\circ\ 50\frac{3}{4}'$	$1^\circ\ 54\frac{1}{4}'$
1873	$1^\circ\ 36\frac{1}{2}'$	$1^\circ\ 38\frac{3}{4}'$	$1^\circ\ 41\frac{1}{4}'$	$1^\circ\ 44'$	$1^\circ\ 47'$	$1^\circ\ 50\frac{1}{4}'$	$1^\circ\ 53\frac{3}{4}'$
1874	$1^\circ\ 36\frac{1}{4}'$	$1^\circ\ 38\frac{1}{2}'$	$1^\circ\ 40\frac{3}{4}'$	$1^\circ\ 43\frac{1}{2}'$	$1^\circ\ 46\frac{1}{2}'$	$1^\circ\ 49\frac{3}{4}'$	$1^\circ\ 53\frac{1}{2}'$
1875	$1^\circ\ 35\frac{3}{4}'$	$1^\circ\ 38'$	$1^\circ\ 40\frac{1}{2}'$	$1^\circ\ 43\frac{1}{4}'$	$1^\circ\ 46'$	$1^\circ\ 49\frac{1}{4}'$	$1^\circ\ 53'$
1876	$1^\circ\ 35\frac{1}{2}'$	$1^\circ\ 37\frac{3}{4}'$	$1^\circ\ 40'$	$1^\circ\ 42\frac{3}{4}'$	$1^\circ\ 45\frac{3}{4}'$	$1^\circ\ 49'$	$1^\circ\ 52\frac{1}{2}'$
1877	$1^\circ\ 35'$	$1^\circ\ 37\frac{1}{4}'$	$1^\circ\ 39\frac{3}{4}'$	$1^\circ\ 42\frac{1}{4}'$	$1^\circ\ 45\frac{1}{4}'$	$1^\circ\ 48\frac{1}{2}'$	$1^\circ\ 52'$
1878	$1^\circ\ 34\frac{3}{4}'$	$1^\circ\ 37'$	$1^\circ\ 39\frac{1}{4}'$	$1^\circ\ 42'$	$1^\circ\ 44\frac{3}{4}'$	$1^\circ\ 48'$	$1^\circ\ 51\frac{3}{4}'$
1879	$1^\circ\ 34\frac{1}{4}'$	$1^\circ\ 36\frac{1}{2}'$	$1^\circ\ 39'$	$1^\circ\ 41\frac{1}{2}'$	$1^\circ\ 44\frac{1}{2}'$	$1^\circ\ 47\frac{3}{4}'$	$1^\circ\ 51\frac{1}{4}'$
1880	$1^\circ\ 34'$	$1^\circ\ 36'$	$1^\circ\ 38\frac{1}{2}'$	$1^\circ\ 41'$	$1^\circ\ 44'$	$1^\circ\ 47\frac{1}{4}'$	$1^\circ\ 50\frac{3}{4}'$

The above table exhibits the angle which the meridian plane makes with the vertical plane passing through the pole-star, when at its greatest eastern or western elongation; such angle is called the *azimuth.* The mean angle only is put down, being calculated for the first of July of each year. The use of the above tables in finding the true meridian will soon appear.

TO FIND THE TRUE MERIDIAN WITH THE THEODOLITE.

121. Take a board, of about one foot square, paste white paper upon it, and perforate it through the centre; the diameter of the hole being somewhat larger than the diameter of the telescope of the theodolite. Let this board be so fixed to a vertical staff, as to slide up and down freely: and let a small piece of board, about three inches square, be nailed to the lower edge of it, for the purpose of holding a candle.

About twenty-five minutes before the time of the greatest eastern or western elongation of the pole-star, as shown by the tables of elongations, let the theodolite be placed at a convenient point and levelled. Let the board be placed about one foot in front of the theodolite, a lamp or candle placed on the shelf at its lower edge; and let the board be slipped up or down, until the pole-star can be seen through the hole. The light, reflected from the paper, will show the cross-hairs in the telescope of the theodolite.

Then, let the vertical spider's line be brought exactly upon the pole-star, and, if it is an eastern elongation that is to be observed, and if the star has not yet reached the most easterly point, it will move from the line toward the east, and the reverse when the elongation is west.

At the time the star attains its greatest elongation, it will appear to coincide with the vertical spider's line for some time, and then leave it, in the direction contrary to its former motion.

As the star moves toward the point of greatest elongation, the telescope must be continually directed to it, by means of the tangent-screw of the vernier plate; and when the star has attained its greatest elongation, great care should be taken that the instrument be not afterward moved.

Now, if it be not convenient to leave the instrument in its place until daylight, let a staff, with a candle or small lamp upon its upper extremity, be arranged at thirty or forty yards from the theodolite, and in the same vertical plane with the axis of the telescope. This is easily effected, by revolving the vertical limb about its horizontal axis, without moving the vernier plate, and aligning the staff to coincide with the vertical hair. Then mark the point directly under the theodolite; the line passing through this point and the staff, makes an angle with the true meridian equal to the azimuth of the pole-star.

From the table of azimuths, take the azimuth corresponding to the year and nearest latitude. If the observed elongation was east, the true meridian lies on the west of the line which has been found, and makes with such line an angle equal to the azimuth. If the elongation was west, the true meridian lies on the east of the line found: and, in either case, laying off the azimuth angle with the theodolite, gives the true meridian.

To find the true Meridian with the Compass.

122. 1. Drive two posts firmly into the ground, in a line nearly east and west; the uppermost ends, after the posts are driven, being about three feet above the surface, and the posts about four feet apart: then lay a plank, or piece of timber three or four inches in width, and smooth on the upper side, upon the posts, and let it be pinned or nailed, to hold it firmly.

2. Prepare a piece of board four or five inches square, and smooth on the under side. Let one of the compass-sights be placed at right angles to the upper surface of the board, and let a nail be driven through the board, so that it can be tacked to the timber resting on the posts.

3 At about twelve feet from the stakes, and in the direction of the pole-star, let a plumb be suspended from the top of an inclined stake or pole. The top of the pole should be of such a height that the pole-star will appear about six inches below it; and the plumb should be swung in a vessel of water to prevent it from vibrating.

This being done, about twenty minutes before the time of elongation, place the board, to which the compass-sight is fastened, on the horizontal plank, and slide it east or west, until the aperture of the compass-sight, the plumb-line, and the star, are brought into the same range. Then if the star depart from the plumb-line, move the compass-sight, east or west, along the timber, as the case may be, until the star shall attain its greatest elongation, when it will continue behind the plumb-line for several minutes; and will then recede from it in the direction contrary to its motion before it became stationary. Let the compass-sight be now fastened to the horizontal plank. During this observation it will be necessary to have the plumb-line lighted: this may be done by an assistant holding a candle near it.

Let now a staff, with a candle or lamp upon it, be placed at a distance of thirty or forty yards from the plumb-line, and in the same direction with it and the compass-sight. The line so determined, makes, with the true meridian, an angle equal to the azimuth of the pole-star; and, from this line, the variation of the needle is readily determined, even without tracing the true meridian on the ground.

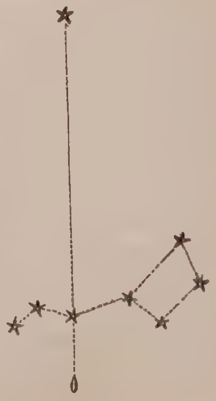
Place the compass upon this line, turn the sights in the direction of it, and note the angle shown by the needle. Now, if the elongation, at the time of observation, was west, and the north end of the needle is on the west side of the line, the azimuth, plus the angle shown by the needle, is the true variation. But should the north end of the needle be found on the east side of the line, the elongation being west, the difference between the azimuth and the angle would show the variation: and the reverse when the elongation is east.

NOTE.—The variation of the needle should always be noted on every survey made with the compass, and then if the land be surveyed at a future time, the old lines can always be re-run.

123. It has been found, by observation, that heat and cold sensibly affect the magnetic needle, and that the same needle will, at the same place, indicate different lines at different hours of the day.

If the magnetic meridian be observed early in the morning, and again at different hours of the day, it will be found that the needle will continue to recede from the meridian as the day advances, until about the time of the highest temperature, when it will begin to return, and at evening will make the same line as in the morning. This change is called the *diurnal variation*, and varies, sometimes, during the summer season, from one-fifth to one-fourth of a degree.

124. A very near approximation to a true meridian, and consequently to the variation, may be had, by remembering that the pole-star very nearly reaches the true meridian, when it is in the same vertical plane with the star Alioth in the tail of the Great Bear, which lies nearest the four stars forming the quadrilateral.



The vertical position can be ascertained by means of a plumb-line. To see the spider's lines in the field of the telescope, at the same time with the star, a faint light should be placed near the object-glass. When the plumb-line, the star Alioth, and the north star, fall on the vertical spider's line, the horizontal limb is firmly clamped, and the telescope brought down to the horizon; a light, seen through a small aperture in a board, and held at some distance by an assistant, is then moved according to signals, until it is covered by the intersection of the spider's lines. A picket driven into the ground, under the light, serves to mark the meridian line for reference by day, when the angle formed by it and the magnetic meridian may be measured.

SECTION IV.

TRIANGULATION.

125. When a large extent of territory, or a long line of sea-coast is to be surveyed, it becomes necessary to consider the curvature of the earth's surface; this branch of surveying is called *Geodesic* surveying.

126. The operations necessary to the successful execution of a Geodesic Survey, require the minutest attention, and when performed, numerous corrections are to be applied to the measured lines and angles, on account of the various causes of error incident to such operations.

To investigate those causes of error, and to deduce rules for correcting the errors, in all cases, would far exceed the limits of an elementary treatise. We shall, therefore, attempt nothing more than a brief outline of the operations in a trigonometrical survey, in which the Plane-Table and Compass are used in connection with the Theodolite, and in which, the curvature of the earth is not considered. We shall then explain the methods of mapping, or plotting, such a survey. The example will be limited to the survey of the harbor, delineated in plate 6.

127. After having made a preliminary examination, or *reconnaissance* of the territory to be surveyed, suitable stations are selected at the most prominent points, and these points are marked by *staves* or *signals*.

A *base-line* is then measured. The length of the base will, in general, depend upon the magnitude of the survey, and each extremity is marked by a signal.

The next step is the *triangulation.* At each extremity of the base, the angles between the base, and the lines drawn to each of the visible signals, are carefully measured by means of a theodolite. The sides of the triangles, thus obtained, serve as new bases upon which other triangles may be formed, and so on, until the entire area is covered by a net-work of triangles.

This system of triangles is called the *primary* system, and the operation of forming them is called the *primary triangulation.* Within the primary triangles, and depending upon them, a system of smaller triangles is formed in the same manner, called the *secondary system;* and if the extent or importance of the work should demand it, the secondary may be subdivided into *tertiary triangles.*

Having completed the triangulation, the characteristics of the surface, such as roads, streams, villages, boundaries, &c., are filled in by means of the compass, plane-table, or some of the methods already explained.

128. Before commencing a trigonometrical survey, an examination of the entire territory should be made, for the purpose of selecting a location for the base-line, and proper points for stations; this examination should be more or less elaborate, according to the nature and extent of the survey.

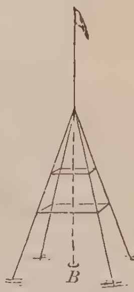
The proper distribution and combination of the triangles, so as to adapt them to the survey in hand, require great judgment and care, and but few rules can be given for the selection of trigonometrical points. Those points should, in general, be chosen in such a manner, that they may be distinctly visible from each other, and so that the triangles formed, by uniting them, may be, as nearly as possible, equilateral.

It is easily seen, that a triangle which has an obtuse or a very acute angle, will experience a greater change of form, for a given error, than one which is nearly equilateral; and since the accuracy of each triangle depends upon the preceding ones, it is further evident, that the introduction of a single ill-conditioned triangle, might vitiate the whole survey. Except in extreme cases, no angle, less than 30°, should be used; and even angles of 30° should not be admitted when the locality can be so chosen as to prevent it. The base is usually much shorter than the sides of the primary triangles; these sides, however, should be increased as rapidly as is consistent with the above remarks.

129. The stations are marked by signals, which may be constructed in a great variety of ways, depending upon the locality of the stations, and the lengths of the sides of the triangles.

Sometimes a signal has to be raised above the level of the adjacent country, in which case it is constructed of timbers, and upon the apex, is placed a vertical staff, bearing a flag. The exact trigonometrical point is determined by a plumb-line, suspended from the apex of the signal.

A temporary signal may be constructed with three or four pieces of scantling framed and traced, as shown in the annexed figure, with a short pole projecting from the apex. The plumb determines the point *B*, which is the exact trigonometrical point over which the theodolite is to be placed. Where the sides of the triangles are not very great, a pole, planted vertically, and surmounted by a flag, will answer as a signal.



In order to distinguish the different signals, the flags which they bear, should be different from each other. They may be formed by arranging stripes of white and red, according to some prearranged plan, and the flags of the different stations should be entered in a book. For the purpose of future reference, the trigonometrical point, at each station, as B, should be indicated by a permanent mark. If the point falls upon a rock, a hole may be drilled to show the locality; or if not, a mark-stone may be sunk under the point, deep enough to be beyond the reach of accident. A record of the monument should be preserved, together with its reference to some of the permanent objects in the neighborhood.

130. The measurement of a base-line on which the accuracy of the entire survey depends, is one of the most difficult operations of surveying, and one, for the successful accomplishment of which, art and science have been strongly taxed. The selection of a proper site for a base-line, forms one of the first objects of the preliminary reconnaissance. It should, if possible, be fixed on an open plain. It must be so chosen, that the surrounding signals may be distinctly seen from its extreme points; and hence, those signals which mark points of the adjacent triangulation, should be selected with reference to the base. The length of the *base*, should, in a measure, depend upon the magnitude of the survey.

THEODOLITE.

131. The theodolite is generally used for measuring the angles of a trigonometric survey. The extent of the survey, and the standard of accuracy to which the results are required to conform, must determine the size and perfection of the instrument to be employed. The angles of the primary triangles of the United States Coast Survey are measured with theodolites, whose horizontal circles are 24 or 30 inches in diameter; and to eliminate, as much as possible, every source of error, great numbers of observations are made at each station, the readings being made on different points of the arc by different verniers. Usually from 40 to 60 observations are made for each angle—one measurement, with the telescope direct, and one with it reverted, constituting a complete observation. With these precautions, it has been found that the error in a primary triangle (where the sum of its three angles has been compared with 180°), has fallen much within 3 seconds. The error of 3 seconds has been adopted as the highest admissible limit of error.

132. To illustrate the manner of carrying on a minor triangulation, let us refer to the plan of the harbor [plate 6], in which *AB* is the measured base, 1140 yards; *C*, *D*, *E*, &c., triangulation points, at which signals have been erected. Commence the triangulation at *A*, the west end of the base; and for convenience in plotting, it would be well to make the line, passing through the 0 point and 180° parallel, in each position of the instrument, to the base *AB*. Having brought the 0 of the vernier to the 0 of the limb, clamp the vernier plate, and direct the upper telescope to the signal at *B*, and clamp the limb. Enter the observations as in the following table:

OBSERVATIONS AT STATION *A*.

Name of Station.	Vernier I.	Vernier II.	Mean.
Station B	00° 00′ 00″	00′ 00″	00° 00′ 00″
Station E	72° 24′ 55″	25′ 5″	72° 25′ 00″
Station G	138° 34′ 56″	35′ 4″	138° 35′ 00″
&c.	&c.	&c.	&c.

Having recorded the reading of the first vernier, and the minutes and seconds of the second vernier, unclamp the vernier plate, and direct the telescope to the station at *E*, and record both verniers, as before. Again unclamp the vernier plate, and direct the telescope on the signal at *G;* and then read and record, as before.

Having determined the angles subtended by all the signals visible from *A*, let the theodolite be removed to *B*. Bring the 0 of the vernier one, to 180° on the limb, and direct the telescope on the signal at *A*—the line (0°, 180°) will then be parallel to its first position, and the limb may be clamped. Read, now, the angles to the signals at *A*, *E*, *C*, &c., and record as before.

If the theodolite is now removed to the station *E*, the line (0°, 180), may be made parallel to its first position, by adding 180° to the reading of the first vernier, from *A* to *E*, and then directing the telescope on the signal at *A*. The line (0°, 180°), will thus be made parallel to *AB*, and the readings may be made and recorded as before; and so on until all the stations have been visited, and the angles measured. From the field records, the angles *BAE*, *EAG*, *ABE*, *EBG*, &c., may be easily deduced, the whole may be plotted on paper, or the several sides may be computed trigonometrically. It may be observed that the line (0°, 180°), has been made parallel to the *base-line* at each station.

133. To illustrate this principle of repetition, suppose the 0 of the vernier to coincide with the 0 of the limb, and the telescope to be directed, from the station *A*, upon one of the objects, as the signal at *B*. Clamp the limb, and unclamping the vernier plate, direct the telescope on the second object, as the signal at *E*. If we now clamp the vernier plate, and unclamping the limb, direct the telescope on the signal at *B*, the line (0°, 180°), of the limb, will make with *AB*, an angle equal to *BAE*. Again clamp the limb, and unclamping the vernier plate, direct the telescope on the signal at *E*. The reading will evidently be equal to twice the angle *BAE;* and if we repeat the operation, the reading will be three times the angle, and so on. After ten repetitions, if we add 360° each time the 0 of the vernier passes the 0 of the limb, the final reading will be ten times the angle *BAE*, affected with the joint errors of the ten observations, and one-tenth of this will be the reading required, to a greater degree of accuracy than could probably be attained by a single observation.

134. The method of reading angles, by this mode, is as follows:

Angles at station *A*, between signals *B* (left), and *E* (right).

June 8th, 1870.

No. of Repetitions.	Vernier I.	Vernier II.	Mean of Verniers.	
1	72° 24′ 55″	25′ 5″	72° 25′ 00″	
2	144° 49′ 55″	50′ 0″	144° 49′ 58″	
3	217° 14′ 50″	15′ 10″	217° 15′ 00″	
4	289° 39′ 50″	40′ 00″	289° 39′ 55″	
				4)289° 39′ 55″
			Mean reading	72° 24′ 59″

Having measured the necessary angles, the parts of all the triangles, formed by joining the stations, three and three, may be readily calculated by methods heretofore explained.

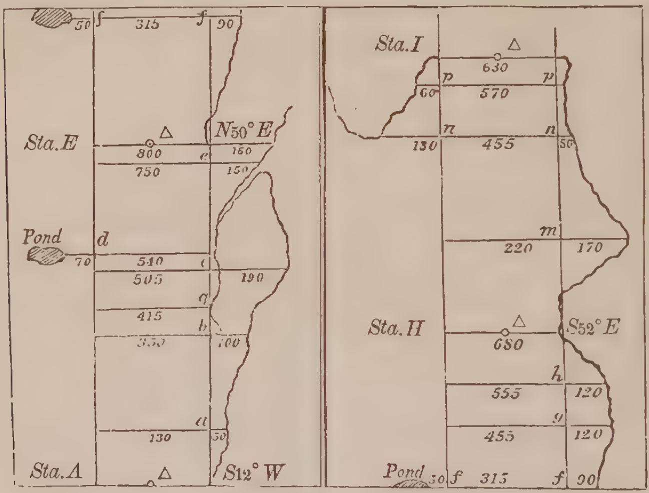
FILLING UP THE SURVEY.

135. After the triangulation is completed, the interior may be filled up by the aid of the Compass, or the plane-table, or both.

USE OF THE COMPASS.

136. The use of the Compass, in determining points and lines, by means of offsets, has been already explained (Bk. II., Art. 83). We will apply these principles, in the example before us.

Place the compass at *A* (plate 6), and take the bearing of the line *AE*, which is S 12° W



Enter this bearing at *A*. Then measure along the line *AE* any distance, as *Aa* equal to 130 yards, and make an offset to the lake, which we measure and find to be 50 yards. Enter the 130 in the middle column, and as the lake lies on the right (in going from *A* to *E*), we insert the 50 in the right-hand column

We then measure along the line *AE* to *b*, 350 yards from *A*. Here we make a second offset to the lake, and find it to be equal to 100 yards. Having entered the distances in the notes, we measure to *q*, the point where the line *AE* crosses the creek, and we enter the distance from *A*, 415 yards.

At *d*, we lay off an offset on the left, to the pond, 70 yards; at *e*, an offset to the mouth of the creek, 150 yards; and at *E*, where the course terminates, an offset to the lake, of 160 yards. The entire distance from *A* to *E* is 800 yards.

At *E*, we take the bearing to *H*, which is N 50° E. Having measured along this line to *f*, 315 yards, we make an offset to the pond, on the left, of 50 yards, and to the shore, on the right, of 90 yards. Having entered these distances, we recommence the notes at 315, below, which we suppose to be at the bottom of the second page. Having reached *H*, the extremity of the course, we enter the entire distance from *E*, 680 yards. We next take the bearing to *I*, S 52° E. We then measure the distances to *m*, *n*, *p*, and *I*, and enter them, together with the offsets, as in the notes.

It is also well to make, in the columns on the right and left, such sketches of the ground, fields, houses, creeks, and rivers, as will afford the means of making an accurate delineation on paper.

The Plane-Table.

137. The plane-table (Pl. 3, Fig. 1) consists of two parts: a rectangular board *CDBA*, and a tripod *EHG*, to which it is firmly secured.

Directly under the rectangular board are four milled screws which pass through sockets inserted in a horizontal brass plate: these screws are worked against a second horizontal plate, for the purpose of levelling the table; the table having a ball-and-socket motion, similar to the limb of the theodolite.

For the purpose of levelling the table, a small detached spirit-level is used. This level being placed over the centre, and also over two of the levelling screws, the screws are turned contrary ways until the level is horizontal; after which, it is placed over the other two screws, and made horizontal in the same manner.

Between the upper horizontal plate and the table, there is a clamp-screw, similar to the clamp-screw of the theodolite, which being loosened, the table can be turned freely about its axis. There is, also, a small tangent-screw, by which the smaller motions of the table are regulated, after the clamp-screw is made fast. Neither of these screws can be seen in the figure.

The upper side of the table is bordered by four brass plates, about one inch in width, and the centre of the table is marked by a small pin, *F*. About this centre, and tangent to the sides of the table, conceive a circle to be described. Suppose the circumference of the circle to be divided into degrees and parts of a degree, and radii to be drawn through the centre and the points of division. The points in which these radii intersect the outer edge of the brass border, are marked by lines on the brass plates, and the degrees are numbered in the direction from left to right, from the point *L* to the point *I*, 180°, and from the point *I* to the point *L*, 180°. In some plane-tables, however, they are numbered from 0 to 360°.

There are, generally, diagonal scales of equal parts cut on the plates *DLC* and *AIB*, the use of which will be explained hereafter.

Near the two other edges of the table, two small grooves are made, into which the plates of brass *DB* and *CA* are fitted, and these plates are drawn to their places by means of milled screws, which pass through the table from the under side, and screw firmly into the plates. The heads of two of the screws, *Q* and *S*, are seen in the figure, as also one of the plates and its two screws in Fig. 3. The object of these plates is to confine a sheet of paper on the table. By loosening the screws, and pressing them upward, the plates are raised above the surface of the table; the edges of the paper can then be placed under them: then, by turning the screws back again, the plates are drawn down and the paper held tightly. Fig. 1 represents the table with the paper partly put upon it: one edge of the paper has been placed under the plate DB, and the screws S and Q tightened. The paper, before being put on, should be moistened, in order to expand it; and then, after it has been dried, it will fit closely to the table.

A ruler, AB (Fig. 2), with open vertical sights, is used with the plane-table. This ruler has a fiducial edge, which is in the same vertical plane with the hairs of the sights. A ruler with a telescope, and a vertical limb, similar to the vertical limb of the theodolite, is sometimes used with the plane-table. A compass, also, is often attached to the table, to show the bearings of the lines.

USES OF THE PLANE-TABLE.

138. The plane-table is used for two distinct objects.

1st. For the measurement of horizontal angles: and,

2dly. For the determination of the shorter lines of a survey, both in extent and position.

TO MEASURE A HORIZONTAL ANGLE.

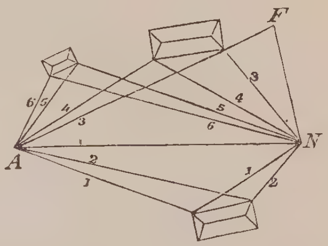
139. Place, by means of a plumb, the centre of the table directly over the angular point: then level the table; after which, place the fiducial edge of the ruler against the small pin at the centre: direct the sights to one of the objects, and note the degrees on the brass plate; then turn the ruler and sights to the other object, and note the degrees as before. If the ruler has not passed over the 0 point, the difference of the readings is the angle sought; but, if it has, take the larger sum from 180°, and to the remainder add the smaller, their sum is the required angle.

TO DETERMINE LINES IN EXTENT AND POSITION.

140. Having placed a paper on the table, examine the objects and lines which are to be determined, and select, for a base, such a line of the triangulation that most of the objects can be seen from its extremities. Then place the plane-table, with its centre, nearly, though not accurately, over one extremity of the base; make it truly horizontal, and turn it until the larger part of the paper lies on the same side of the base, with the objects.

Then, tighten the clamp-screw, and mark with a pointed pin the point of the paper directly over the station, which point is determined most accurately by suspending a plumb from the lower side of the table. Press the pin firmly on this point, bring the fiducial edge of the ruler against it, and sight to the other extremity of the base-line, and mark, with the pin or pencil, the direction of the line on the paper. Sight, in like manner, to every other object, and draw on the paper the corresponding lines, numbering them from the base-line, 1, 2, 3, 4, &c.

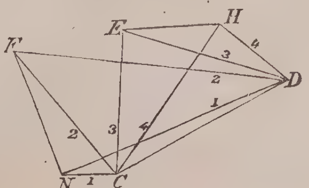
Then, with a pair of dividers, take from the scale a certain number of equal parts, to represent the base, and lay off the distance on the base-line from the place of the pin. Take up the table, carry it to the other extremity of the base, and place the point of the paper corresponding to that extremity, directly over it. Place the fiducial edge of the ruler on the base-line, and turn the table, by means of the tangent-screw, until the sights are directed to the first station. If, however, in bringing the table to this position, the corresponding point of the paper has been moved from over the extremity of the base-line, move the legs of the tripod until it is brought back to its place. Let the table be then levelled, after which, place the ruler again on the base-line, and bring the table to its proper position, by the tangent-screw, and continue the adjustment until the extremity of the base-line, on the paper, is directly over the station, and in the same vertical plane with the base-line, on the ground. Then direct the sights to all the objects sighted to, from the other station, and mark the lines 1, 2, 3, 4, &c., from the base-line, as before. The intersections of the corresponding lines 1,1, 2,2, 3,3, 4,4, &c., determine, on the paper, the positions of the several objects, and a reference of these lines to the scale of equal parts, determines the true distances.



141. Let it be required, for example, to determine, by means of the plane-table, the relative positions of several houses.

From station *A*, and on one of the lines of the triangulation, as *AB*, measure the base-line *AN*, which we will suppose equal to 300 yards. Place the plane-table at *A*, and sight to the corners of the houses, and mark the lines 1, 2, 3, 4, &c. Then remove the table to *N*, and sight to the same corners as before, and draw the lines as in the figure. The points at which they intersect the corresponding lines, before drawn, determine the corners of the houses. The front lines of the houses may then be drawn on the paper. Draw lines at right angles to the front lines, and on them lay off the depths of the houses, with the same scale as that used for the base-line.

To find the length of any line drawn on the paper, as the line 1, drawn through *A*, for example, place the dividers at *A* and extend them to the other extremity of the line, and then apply the line to the scale. The length of the line 1 is equal to 198 yards.



142. In this example, we determine from the base-line *CD*, the positions of the points *F*, *E*, and *H*.

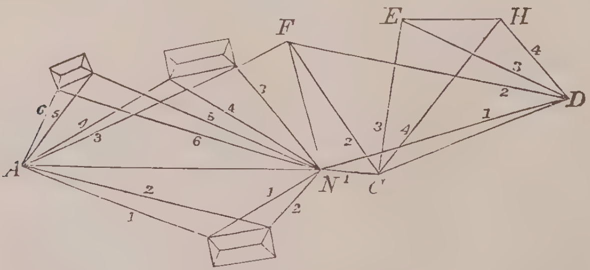
Changing the Paper.

143. When one paper is filled, and there is yet more work to be done, let the paper be removed, and a second paper put on the table; after which, the table may be used as before.

Now, in order that the two papers may be put together and form one entire plan, it is necessary that two points, determined on the first paper, be also determined on the second; and then, by placing the lines joining these points, one on the other, all the lines on the two papers will have the same relative position as the corresponding lines on the ground; and the same for as many papers as it may be necessary to use. If different scales are used, the corresponding points will not join, and then the work must be reduced to the same scale, before the papers can be put together.

In the first example, the position of the point F was determined, in order to unite the first paper with the second.

In the second example, we sighted from C and D, the extremities of the base-line, to the points N and F, determined on the first paper; we thus determined the line NF on the second paper. Placing the line NF of the one paper on NF of the other, we have the following plan.



In this plan, all the points and lines are accurately laid down. Any number of papers may be joined in a similar manner.

144. The principal use of the plane-table is for the interior filling up of trigonometrical surveys; it is also used with advantage, when only a plot of a field is wanted.

It ought not be used for the determination of long lines, nor can it be relied on for determining extended areas.

Plotting the Triangulation.

145. The sides of the triangles having been completed, the work may then be plotted, as already explained, either by means of the circular protractor, or by the method of chords.

The Circular Protractor.

146. This instrument consists of a brass circular limb (Pl. 2, Fig. 4), of about six inches in diameter, with a movable index AB, having a vernier at one extremity A, and a milled screw at the other extremity B, with a concealed cog-wheel that works with the cogs of the limb, and thus moves the index AB about the centre of the protractor. At the centre of the protractor is a small circular glass plate, on which two lines are cut; the point of their intersection is the exact centre of the instrument. The limb is generally divided to half-degrees; the degrees are numbered from 0 to 360.

At the 0 point, and at the opposite extremities of the diameter passing through that point, are small lines on the inner edge of the limb; the two extremities of the diameter, perpendicular to this latter, are designated in the same way.

Two angular pieces of brass, each having a small and sharp steel pin at its extremity, are fastened to the index, and revolve freely around the lines *ab* and *cd*. The small screws, *a*, *b*, *c*, and *d*, move them in the directions of the lines *ab*, *cd*, for the purpose of bringing the steel pins exactly into the line which passes through the 0 of the index and the centre of the protractor.

To adjust them to their places, place the centre of the protractor over a marked point, and the 0 of the index to the 0 of the limb. Then mark the place of the index by the pins; after which, turn the index 180°, and see if the pins will mark the same points as before. If they do, the index is adjusted; if they do not, correct the error with the screws *a*, *b*, *c*, and *d*.

To lay off an Angle with the Protractor.

147. Let its centre be placed over the angular point, and the diameter passing through 0 and 180°, on the given line. Turn the screw that works the index, until the 0 of the vernier coincides with the division corresponding to the given angle; then let the angular brass pieces be turned down; the points dotted by the steel pins will show the direction of the required line.

If this line does not pass through the angular point, the pins are out of place, and must be re-adjusted.

First Method of Plotting.

148. Suppose it were required to make the plot of the harbor on a scale of 450 yards to an inch.

Divide the length of the base-line *AB*, which is equal to 1140 yards, by 450, and the quotient 2.53 will express the length which is to represent the base-line on the paper (Bk. I., Art. **39**).

Draw an indefinite line *AB*, to represent the base; and having chosen any point, as *A*, for the first station, lay off 2.53 inches to *B*. The other extremity of the base-line will thus be determined.

Then, place the circular protractor at *A*, and lay off the angle *BAE*, and then the angle *EAG*. Next, place the protractor at *B*, and lay off the angles *ABE* and *EBC*. The intersection of the lines *AE* and *BE* will determine the station *E*. Let the protractor be then placed at this point, and all the angles of station *E* laid down.

The point *G*, where *EG* intersects *AG*, and the point *C*, where *EC* intersects *BC*, will then be found.

By placing the protractor at *C* and *G*, we can determine the points *D* and *F*, when the place, on the paper, of all the stations will be known.

To unite the work done with the compass, spread the compass-notes before you, and draw through *A* a line to represent the meridian. The course *AE* lies to the west of this meridian, and makes an angle of 12° with it.

Then, lay off from the scale the distances *Aa*, *Ab*, *Aq*, *Ac*, *Ad*, *Ae*, and at the several points erect perpendiculars to *AE*. Lay off, on these perpendiculars, the lengths of the offsets, and the curve traced through the points so determined, will be the margin of the lake.

At *E*, draw a parallel to the meridian through *A*, and lay down the course *EH*, which is easterly, and makes an angle of 50° with the meridian. Then, lay down the several distances to the offsets, and draw the offsets and lay off their lengths. Do the same for the course *HI*, and all the compass-work will be plotted.

The work done with the plane-table is united to the work done with the theodolite, by simply reducing it to the same scale, and then placing the line *AN* on the paper of the plane-table, upon the line *AN*, drawn on the plot of the triangulation.

SECOND METHOD OF PLOTTING.

149. Place the centre of the protractor near the centre of the paper, and draw a line through the points 0 and 180°. This line will have the same position with the circular protractor that the base-line *AB* had with the limb of the theodolite.

Then lay off, from the 0 point, an arc equal to the direction from *A* to *E*, also an arc equal to the direction *AG*, and through the centre point, and the points so determined, draw lines. Lay off in succession, in a similar manner, the directions taken at all the stations; and through the centre point, and the points so determined, draw lines, and designate each by the letters of the direction to which it corresponds.

Now, since all the lines drawn on the paper have the same position with the circular protractor, as the corresponding lines on the ground have with the limb of the theodolite, it follows that each direction will be parallel to its corresponding line upon the ground.

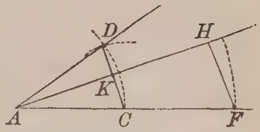
Hence, any line may be drawn parallel to that passing through 0 and 180°, to represent the base-line *AB*. Having drawn such a line, and marked a point for the station *A*, lay off the length of the base, and the extremity will be the station *B*.

Through *A* and *B*, so determined, draw parallels respectively to the lines corresponding to the directions *AE* and *BE*, and the point of intersection will determine station *E*. Through *B* and *E*, draw parallels to the lines which correspond to the directions *BC*, *CE*, and their point of intersection will determine station *C*. Through *C* and *E*, draw lines parallel to the lines corresponding to the directions *CE* and *ED*, and the point of intersection will determine *D*. In a similar manner we may determine the stations *F* and *G*.

METHOD OF CHORDS.

150. The chord of a given arc is equal to the sine of half the arc with double the radius.

For, let *DAF* be any given angle, and *AH* a line bisecting it. Let *DC* be the chord of the arc *CD*, described with a given radius, and *HF* parallel to *CD*, the sine of half the given angle, to a radius $AF = 2AC$.

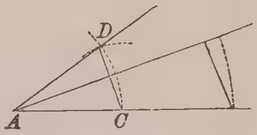


Since $AF = 2AC$, we have, from similar triangles, $HF = 2KC$; but $DC = 2KC$, hence $HF = CD$.

To lay off an Angle.

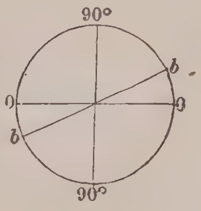
151. To avoid, as far as possible, the use of fractions, let us suppose the radius of the table of natural sines to be 1 *ten*, or 10 inches.

Take, from a scale, 5 equal parts, with which, as a radius, from the centre *A*, describe an arc *CD*. Take from the table the natural sine of half the arc, and remove the decimal point one place to the right; the result will express the sine of half the arc to the radius 10, or the chord of the arc to the radius 5. From the same scale, take this sine in the dividers, and from *C*, as a centre, describe an arc cutting *CD* in *D*; draw *AD*, and *CAD* will be the angle required.



This is the most accurate of all the methods of laying off an angle, and it may also be applied advantageously to the second method of plotting, thus:

Draw a fine straight line, generally in the direction of the meridian or of the base-line of the survey; and also a line perpendicular to it. From the point of intersection, as a centre, with a radius of 5 equal parts of the scale, describe the



circumference of a circle cutting the straight lines in the points marked 0 and 90°.

To lay off an angle, as, for instance, the angle 14° 29′. The half of it is 7° 14′ 30″, the natural sine of which is 0.126005, or 1.26 to the radius of 10 inches. Set off from 0 to *b*, as in the figure, this distance taken from the scale, and through the two points *b*, *b*, thus determined, draw a straight line. This line should pass through the centre, and will make with the line (0, 0) the angle 14° 29′; and any line on the paper drawn parallel to it, will make with the line (0, 0) the same angle. The further application is obvious.

MARITIME SURVEYING.

152. When, in connection with a trigonometrical survey on shore, a harbor is to be surveyed, as in the example, for the purpose of ascertaining the channels, their depth and width, the positions of shoals, and the depth of water thereon, other means must be used, and other examinations made, in addition to those already described.

Let buoys be anchored on the principal shoals and along the edges of the channel; and using any one of the lines already determined as a base, let the angles subtended by lines drawn from its extremities, to the buoys respectively, be measured with the theodolite. Then, there will be known, in each triangle, the base and angles at the base, from which the distances to the buoys are easily found; and hence, their positions become known.

Having made the soundings, and ascertained the exact depth of the water at each of the buoys, several points of the harbor are established, at which the precise depth of the water is known; and by increasing the number of the buoys, the depth of the water can be found at as many points as may be deemed necessary.

153. If a person with a theodolite, or with any other instrument adapted to the measurement of horizontal angles, be stationed at each extremity of the base-line, it will not be necessary to establish buoys. A boat, provided with an anchor, a sounding-line, and a signal-flag, has only to throw the anchor, hoist the signal-flag, and make the sounding, while the persons at the extremities of the base-line measure the angles. From these data, the precise place of the boat can be determined.

154. There is another method of determining the places at which the soundings are made, that admits of great despatch, and which, if the observations are made with care, affords results sufficiently accurate.

Having established, trigonometrically, three points which can be seen from all parts of the harbor, and having provided a sextant, let the sounding be made at any place in the harbor, and at the same time the three angles subtended by lines drawn to the three fixed points, measured with the sextant.

The problem, to find, from these data, the place of the boat at the time of the sounding, is the same as example 6, p. **93**.

It is only necessary to measure two of the angles, but it is safest to measure the third also, as it affords a verification of the work.

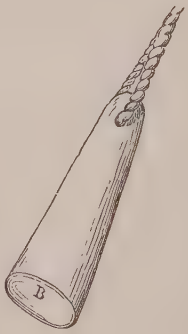
The great rapidity with which angles can be measured with the sextant, by one skilled in its use, renders this a most expeditious method of sounding and surveying a harbor.

The sextant is not described, nor are its uses explained in these Elements, because its construction combines many philosophical principles, with which the Surveyor cannot be supposed conversant.

155. There is yet another method of finding the soundings, which, although not as accurate as those already explained, will, nevertheless, afford results approximating nearly to the truth. It is this:—Let a boat be rowed, with uniform speed, across the harbor, from one extremity to the other of any of the lines determined trigonometrically. Let soundings be made continually, and let the precise time of making each be carefully noted. Then, knowing the length of the entire line, the time spent in passing over it, as also the time of making each of the soundings, we can easily find the points of the line at which the several soundings were made; and hence, the depth of water at those points becomes known.

156. If a person stationed on shore with a theodolite, takes the bearing of the boat, at every second or third sounding, determined by hoisting a flag, it will fix the positions of the soundings with great accuracy. Soundings may thus be made along any number of known lines, and a comparison of the depths found, on different lines, at or near their points of intersection, will show with what degree of accuracy the work has been done.

Sounding-lines should be made of strong cord, and divided into feet or fathoms, by different colored rags or other marks. The lead is shaped like the frustum of a cone, with the base *B* hollowed out, to hold some grease. The land or mud of the bottom adheres to the grease, and thus shows the nature of the bottom, which should be entered in the field-book, and laid down upon the map. As the cord is liable to change its length, it should be compared, from time to time, with some standard. In tide-waters, the exact time of each sounding is to be noticed, and an assistant should note the height of the tide at regular intervals, upon a tide-gauge. The tide-gauge is permanently placed at some convenient point of the harbor, and its 0 point is referred, by



means of a spirit-level, to some fixed bench-mark, on a level with mean low-water mark, to which all the soundings must be reduced.

157. Having plotted the work done with the theodolite, as also the outline of the harbor traced with the compass, it remains to delineate the bottom of the harbor; and this is done by means of horizontal curves, hereafter explained, (Bk. III., Art. **29**), which are used to represent broken or undulating ground.

Let the plane of reference be taken through low-water mark, or to coincide with the surface of the water, at low tide. The accuracy with which the bottom of the harbor is to be delineated, will guide us in fixing the distance between the horizontal planes of section.

The first horizontal plane should be passed at a distance below the shallowest point that has been sounded, equal to the number of feet fixed upon for the distance between the planes of section; and the curve, in which it intersects the bottom of the harbor, determined as in Book III., Art. **25.** And similarly, for the other horizontal planes of section.

Having thus delineated the bottom of the harbor, and noted on the map the distance of each intersecting plane below the plane of reference, let such lines be drawn as will indicate the channels, shoals, sunken rocks, and direction of the current.

In the example given in Plate 6, soundings have been made in three directions, from the sand-bar in the harbor, and also from the rocky shore across to the light-house.

BOOK III.

LEVELLING AND ITS APPLICATIONS.

SECTION I.

OF LEVELLING.

1. LEVELLING is the art of determining the relative distances of points from the centre of the earth.

2. A line whose points are all equally distant from the centre of the earth, is called a line of *true level;* and a surface, all whose points are equally distant from the centre of the earth, as the surface of still water, is called a *level surface.*

3. One point is said to be above another, when it is farther from the centre of the earth; and this difference of distance from the centre, is called the *difference of level* between the two points.

4. A straight line drawn tangent to a line of true level, at any point, is a horizontal line, and is called the line of *apparent level.* Thus, (Pl. 4, Fig. 1), if C is the centre of the earth, and AEF a line of true level, ABD is the line of apparent level. This is the line of level determined by an instrument. The difference between the apparent and true level of the points A and E, is BE, the *excess* of the secant CB, of the arc AE, over the radius CE.

5. To find a general formula for computing this excess, we have (Geom., B. IV., Prop. XXX.),

$$\overline{AB}^2 = BE\ (BE + 2EC);$$

but, since the arc AE is very small in comparison with the radius of the earth, the arc AE will not differ sensibly from the tangent AB; the diameter $2EC$ may, for the same reason, be taken for the secant $(BE + 2EC)$: hence,

$$\overline{AE}^2 = BE \times 2EC, \quad \text{or,} \quad \text{dividing by } 2EC,$$

$$BE = \frac{\overline{AE}^2}{2EC} \quad . \; . \; . \; . \; . \; (1).$$

If we take the mean diameter of the earth to be 7919 miles,

formula (1) gives $$BE = \frac{\overline{AE}^2}{7919} \quad . \; . \; . \; . \; . \; (2),$$ hence,

The departure of the apparent from the true level, starting from a given point, is equal to the square of the distance to the second point, divided by the diameter of the earth.

If, in formula (2), we give to AE, in succession, every value from 1 chain to any given number of chains (say 100), and reduce, at the same time, both terms of the fraction to inches, a table may be computed as on next page.

Observe, that when the distance $AE = 80$ chains $= 1$ mile, that BE is $= 8.001$ inches, or two-thirds of a foot, very nearly; and for any other distance, d, *in miles*, we have,

$$1^2 \ : \ d^2 \ :: \ \tfrac{2}{3} \text{ of a foot } \ : \ \tfrac{2}{3}d^2;$$

hence, we have the following easy rule for finding the correction of curvature in feet:

The correction for curvature, in feet, is equal to two-thirds of the square of the distance in miles.

Table showing the differences, in inches, between the true and apparent level, for distances between 1 and 100 chains.

Chains.	Inches.	Chains.	Inches.	Chains.	Inches.	Chains.	Inches.
1	.001	26	.845	51	3.255	76	7.221
2	.005	27	.911	52	3.380	77	7.412
3	.011	28	.981	53	3.511	78	7.605
4	.020	29	1.051	54	3.645	79	7.802
5	.031	30	1.125	55	3.781	80	8.001
6	.045	31	1.201	56	3.925	81	8.202
7	.061	32	1.280	57	4.061	82	8.406
8	.080	33	1.360	58	4.205	83	8.612
9	.101	34	1.446	59	4.351	84	8.832
10	.125	35	1.531	60	4.500	85	9.042
11	.151	36	1.620	61	4.654	86	9.246
12	.180	37	1.711	62	4.805	87	9.462
13	.211	38	1.805	63	4.968	88	9.681
14	.245	39	1.901	64	5.120	89	9.902
15	.281	40	2.003	65	5.281	90	10.126
16	.320	41	2.101	66	5.443	91	10.351
17	.361	42	2.208	67	5.612	92	10.587
18	.405	43	2.311	68	5.787	93	10.812
19	.451	44	2.240	69	5.955	94	11.046
20	.500	45	2.531	70	6.125	95	11.233
21	.552	46	2.646	71	6.302	96	11.521
22	.605	47	2.761	72	6.480	97	11.763
23	.661	48	2.880	73	6.662	98	12.017
24	.720	49	3.004	74	6.846	99	12.246
25	.781	50	3.125	75	7.032	100	12.502

INSTRUMENTS.

6. Before proceeding further in the discussion of the principles of levelling, we will describe some of the instruments used, and first,

THE Y LEVEL.

7. *A Level* is an instrument used to indicate a horizontal line, and also, to determine the difference of level of any two points on the surface of the earth.

The part of the instrument shown in (Pl. 4, Fig. 2), rests on a tripod, to which it is permanently attached at Z. *HH* is a horizontal brass plate, through which four levelling-screws with milled heads are passed, and worked against a second horizontal plate, *GG*. Two of these screws, *K* and *I*, are seen in the figure. *S* is a clamp-screw, which, being loosened, allows the upper part of the instrument to turn freely around its axis. Q is a tangent-screw, by means of which the upper part of the instrument is moved gently, after the clamp-screw *S* has been made fast. *EE* is a horizontal bar, perpendicular to which are the wyes, designated Y's, that support the telescope *LB*. This telescope is confined in the Y's by the loops *r*, *r*, which are fastened by the pins *p* and *p*. The object-glass *B*, is adjusted to its focus by the screw *X*, the eye-glass *L* slides out and in, freely. The screws *f*, *f*, work the slide which carries the horizontal hair; and two horizontal screws, only one of which, *a*, is seen, work the slide that carries the vertical hair. *CD* is an attached spirit-level. The screw *N* elevates and depresses the Y nearest the eye-glass. In some instruments this Y is elevated and depressed, by means of two screws at *M* and *R*.

Before using this level, it must be adjusted. The adjustment consists in bringing the different parts to their proper places.

The line of *collimation* is the axis of the telescope. With this axis, the line drawn through the centre of the eye-glass and the intersection of the spider's lines, within the barrel of the telescope, ought to coincide.

FIRST ADJUSTMENT.

To fix the intersection of the spider's lines in the axis of the telescope.

8. Having screwed the tripod to the instrument, extend the legs, and place them firmly. Then loosen the clamp-screw *S*, and direct the telescope to a small, well-defined, and distant object. Then slide the eye-glass till the spider's lines are seen distinctly; after which, with the screw *X*, adjust the object-glass to its proper focus, when the object and the spider's lines will be distinctly seen. Note now the precise point covered by the intersection of the spider's lines.

Having done this, revolve the telescope in the Y's, half round, when the attached level *CD* will come to the upper side. See if, in this position, the horizontal hair appears above or below the point, and in either case, loosen the one, and tighten the other, of the two screws which work the horizontal hair, until it has been carried over half the space between its last position and the observed point. Carry the telescope back to its place; direct again, by the screws at *M* and *R*, the intersection of the spider's lines to the point, and repeat the operation, till the horizontal hair neither ascends nor descends while the telescope is revolved. A similar process will arrange the vertical hair, and the line of collimation is then adjusted.

SECOND ADJUSTMENT.

To make the axis of the attached level CD parallel to the line of collimation.

Turn the levelling-screws *M* and *R*, until the bubble of the level *DC* stands at the middle of the tube. Then open the loops, and reverse the telescope. If the bubble still stands at the middle of the tube, the axis of the level is horizontal; but if not, it is inclined, the bubble being at the elevated end. In such case, raise the depressed, or depress the elevated end, by means of the small screw *h*, half the inclination; and then with the screws, at *M* and *R*, bring the level to a horizontal position. Reverse the telescope in the Y's, and make similar corrections again; and proceed thus, until the bubble stands in the middle of the tube, in both positions of the telescope; the axis of the level is then horizontal.

Let the telescope be now revolved in the Y's. If the bubble continues in the middle of the tube, the axis of the level is not only horizontal, but also parallel to the line of collimation. If, however, the bubble recedes from the centre, the axis of the level is inclined to the line of collimation, and must be made parallel to it, by means of two small screws, which work horizontally; one of these screws is seen at *q*. By loosening one of them, and tightening the other, the level is soon brought parallel to the line of collimation; and then, if the telescope be revolved in the Y's, the bubble will continue at the middle of the point of the tube. It is, however, difficult to make the first part of this adjustment, while the axis of the level is considerably inclined to the line of collimation; for, even if the level be truly horizontal in one position of the telescope, after it is reversed, there will be but one corresponding position in which the bubble will stand at the middle of the tube. This suggests the necessity of making the first part of the adjustment with tolerable accuracy; then, having made the second with care, re-examine the first, and proceed thus till the adjustment is completed.

THIRD ADJUSTMENT.

To make the level CD and the line of collimation perpendicular to the axis of the instrument, or parallel to the horizontal bar EE.

Loosen the clamp-screw *S*, and turn the bar *EE*, until the level *DC* comes directly over two of the levelling screws. By means of these screws, make the level *CD* truly horizontal. Then, turn the level quite round; if, during the revolution, it continue horizontal, it must be at right angles to the axis of the instrument about which it has been revolved. But if, after the revolution, the level *CD* be not horizontal, rectify half the error with the screws at *M* and *R*, and half with the levelling screws. Then place the bar *EE* over the other two levelling screws, and make the same examinations and corrections as before; and proceed thus, until the level can be turned entirely around without displacing the bubble at the centre. When this can be done, it is obvious that the level *DC* and the line of collimation, are at right angles to the axis of the instrument, about which they revolve; and since the axis is carefully adjusted by the maker, at right angles to the bar *EE*, it follows, that the line of collimation, the level *DC*, and the bar *EE*, are parallel to each other.

The level is now adjusted. When used, however, it is best to re-examine it every day or two, as the work will be erroneous unless the instrument is accurately adjusted.

Levelling Rods.

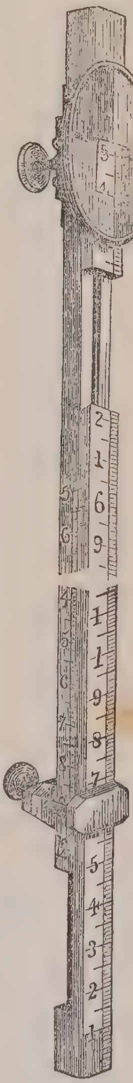
9. The levelling rods are used to determine the points at which a given horizontal line intersects lines that are perpendicular to the surface of the earth, and to show the distances of such points of intersection from the ground.

There are two kinds of rods used by engineers, known as the Boston and New York rods.

They are both sliding rods, divided into feet, tenths, and hundredths of feet; and the readings, by means of a vernier, are made to thousandths of a foot.

10. The Boston Rod is formed by two pieces of hard wood, about six feet and a half in length, the one sliding through grooves, along the other, in both directions.

A *vane* or *target*, six-tenths of a foot in width, divided into four equal rectangles by a horizontal and vertical line, passing through the centre, is permanently connected with one extremity of the sliding piece. The two diagonal rectangles of the target, are usually painted black or red, and the other two white, so that the centre and the horizontal dividing line, may be distinctly seen.



There are two verniers, one at either end of the second piece, by means of which the readings, indicating the height of the target, are read.

When the height is less than six feet, the reading is made by the vernier at the top of the rod; and when it is greater than six feet, the rod is reversed, which brings the other vernier to the top; the target is then run up to the required height, and the reading made as before.

New York Rod.

11. This rod, which is shown in the engraving, is cut in two parts, so that both ends may be exhibited. It is made of satin-wood, in two pieces, like the former, but sliding one from the other, always in the same direction, so that the same end is always held on the ground, and the graduations start from that point. In this rod, as in the other, a target is used to indicate where the horizontal line cuts the rod.

The face of the target is divided into quadrants, by a horizontal and a vertical diameter; and these diameters are the boundaries of the alternate colors with which the diagonal quadrants are painted.

The opening, in the face of the target, is a little more than the tenth of a foot. The right edge of the opening is chamfered, and divided into ten equal spaces, corresponding to nine hundredths on the rod: hence, the vernier reads to thousandths of a foot. For heights less than six feet, the target is moved along the sliding part, to which it is slightly attached by springs, and to which it may be permanently attached by a clamp-screw, and the reading is made by the vernier on the target. When the height exceeds six feet, the slide and target are run up to the requisite height, and the reading is made by the vernier at the top of the staff.

Tests of Adjustment.

12. There is a method of testing the adjustments of the Y level, which ought not to be neglected, since all the results depend on the accuracy of the instrument. The method is this:

The level being adjusted, place it at any convenient point, as *G* (Pl. 4, Fig. 4). At equal distances of about 100 yards, on either side, and in the same line with the level, place the levelling rods, *Cb*, *BF*. Make the level horizontal with the levelling screws. Then, turn it toward either rod, as *BF*, and run the vane up or down, as required, until the intersection of the hairs strikes the centre: then make the slide fast, and note carefully the height of the vane. Turn the level half round, and do the same in respect of the staff *Cb*.

Let the telescope be now reversed in the Y's. Sight again to the rod *BF*, and note the exact height of the vane. Let the telescope be now turned half round, and the same be done for the rod *Cb*. If the two heights last observed are equal to those first noted, each to each, the line of collimation is perpendicular to the axis of the instrument; and if the bubble has, at the same time, preserved its place at the middle point of the tube, the instrument is truly adjusted.

For, had the line of collimation been inclined to the axis of the level, it would, in the first instance, have taken the direction *AF* or *Ad;* and when turned half round, it would have taken the direction *AE* or *Ab.* The telescope being reversed in the Y's, and again directed to the staff *BF*, the line of collimation would take the direction *Ad* or *AF*, and when turned to the staff *Cb*, it would take the direction *Ab* or *AE:* and the two distances *BF*, *Bd*, or *Cb*, *CE*, can only be equal to each other when the line of collimation falls on the horizontal line *gf*.

Levelling in the Field.

13. The operations of levelling may be undertaken:

1st. For the purpose of determining the difference of level between two given points:

2d. For the purpose of obtaining a section or profile along a given line, as in the preliminary surveys for railroads and canals:

3d. For the purpose of determining the contour lines in a topographical survey, as described in Section II.; and,

4thly. For the purpose of determining the volume of any given mass of earthwork or masonry; as the measurement of excavations and embankments for canals and railroads: and,

5thly. For the purpose of determining and indicating boundaries for filling and excavation; such as setting stope stakes, &c.

Difference of Level between two Points.

14. When it is proposed to find the difference of level of any two objects, or stations, all levels made in the direction of the station at which the work is begun, are called, for the sake of distinction merely, *back-sights;* and levels taken in the direction of the other station, *fore-sights.*

Before going on the field with the level, rule three columns, as below, and head them, stations, back-sights, fore-sights.

FIELD NOTES.

Stations.	+ Back-Sights.	— Fore-Sights.
1	10	3
2	11.6	0
3	6.8	4.9
4	3.9	8.3
Sums	32.3	16.2
	16.2	
Dif. of level . .	16.1	

EXAMPLES.

Find the difference of level between any two points, as A and G (Pl. 4, Fig. 5).

The level being adjusted, place it at any point, as *B*, as nearly in the line joining *A* and *G*, as may be convenient. Place a levelling rod at *A*. Make the level horizontal by means of the levelling screws; turn the telescope to the rod at *A*, and direct the rodman to raise the target until the horizontal line *ab* pierces its centre; then note the distance *Ab* (equal to 10 feet in the present example) and enter it in the column of back-sights opposite station 1.

Send the rodman forward to some point, as *N*, in the proposed direction, and sight to the rod as before; enter the distance *Na*, equal to 3 feet, in the column of fore-sights opposite station 1, (*B*). Then remove the level to a convenient point, as *C*, (2). Direct the rodman to run up the vane to the proper height; then make the back-sight, and enter it, $Nd = 11.6$ feet, in the column of back-sights, opposite station 2. Let the rod-man then be sent forward to a convenient point, as M, and make the fore-sight to f; and enter $Mf = 0$, in the column of fore-sights, opposite station 2, (C). Remove the level, in succession, to D and E, and make similar levels at those points, and enter the results in the columns of back-sights and fore-sights, opposite stations 3, (D), and 4, (E).

It is evident from the figure, that the difference of level NF, between A and N, is equal to the back-sight bA, diminished by the fore-sight aN; also that the difference of level between N and M, is equal to the back-sight dN, diminished by the foresight 0, and since each set of observations is entirely independent of every other set, we may infer that *the difference of level between two consecutive points, as determined by the same position of the level, is equal to the back-sight, diminished by the fore-sight.* If the fore-sight be greater than the back-sight, the difference will be affected with a *minus* sign, a result which shows that the second point is lower than the first: and,

Generally, *the difference of level between any two points, determined as above, is equal to the sum of the back-sights diminished by the sum of the fore-sights.* If the result is plus, the second point is higher than the first; if negative, it is lower.

In the example given, the difference of level between A and G, is 16 feet and 1 tenth.

15. In the above example, we did not regard the difference between the true and apparent level. If it be necessary to ascertain the result with extreme accuracy, this difference must be considered: and then, the horizontal distances between the level, at each of its positions, and the rods, must be measured, and the apparent levels diminished by the differences of level; which differences can be found from the table.

EXAMPLE.

Stat.	Back-sts.	Distances.	Fore-st.	Distances.	Cor. back-sts.	Cor.for-sts.
1	9.8	20 ch.	1.6	32 ch.	9.7583	1.4933
2	8.7	25 ch.	2.4	28 ch.	8.6349	2.3183
3	5.2	18 ch.	3.1	16 ch.	5.1663	3.0734
4	10.3	29 ch.	1.9	87 ch.	10.2124	0.1115
5	11.0	45 ch.	2.5	72 ch.	10.7891	1.9600
					44.5610	8.9565

In this example, the first column shows the stations; the second, the back-sights; the third, the distances from the level in each of its positions to the back rod; the fourth, the fore-sights; the fifth, the distances from the level to the forward rod; the sixth and seventh, are the columns of back and fore sights, corrected by the difference of level. The corrections are thus made: The difference of level in the table corresponding to 20 chains, is 5 tenths of an inch, or .0417 of a foot nearly; which being subtracted from 9.8 feet, leaves 9.7583 feet for the corrected back-sights; this is entered opposite station 1 in the sixth column. The difference of level corresponding to 32 chains, is 1.280 inches, or .1067 feet, nearly; which being subtracted from the apparent level, 1 foot 6 tenths, leaves 1.4933 feet, for the true fore-sight from station 1. The other corrections are made in the same manner.

The sum of the back-sights being 44.5610 feet, and the sum of the fore-sights 8.9565 feet, it follows, that the difference, 35.6045 feet, is the true difference of level.

16. In finding the true from the apparent level, we have not regarded the effect caused by refraction on the apparent elevation of objects, as well because the refraction is different in different states of the atmosphere, as because the corrections are inconsiderable in themselves.

17. The small errors that would arise in regarding the apparent as the true level, may be avoided *by placing the levelling rods at equal distances from the level.* In such case, it is plain, 1st, that equal corrections must be made in the fore and back-sights; and, 2dly, that when the fore and back-sights are diminished equally, the result, which is always the difference of their sums, will not be affected.

This method should always be followed, if practicable, as it avoids the trouble of making corrections for the difference of true and apparent level.

The differences between the true and apparent level, being very inconsiderable for short distances, if only ordinary accuracy be required, it will be unnecessary to make measurements at all. Care, however, ought to be taken, in placing the levelling rods, to have them as nearly *equidistant from the level* as can be determined by the eye; and if the distances are unequal, let the next distances also be made unequal; that is, if the back-sight is the longer in the first case, let it be made proportionably shorter in the second, and the reverse.

LEVELLING FOR SECTION.

18. Having decided upon the line along which a section is to be taken, let a permanent mark be made at the beginning of the line: this is called, a *bench-mark.* A bench-mark is made by drilling a hole in a rock, or by painting upon a rock or fence, or sometimes by driving a stake in the ground, with its upper end marked by a nail-head. Bench-marks should be made from time to time along the line, to serve as checks, in case a re-survey should become necessary.

The operations in the field are similar to those in the last example, and the field-notes are kept in the same manner, except that a new column is added for bearings, when it is necessary to make a plot of the line of survey. The total distance of each point, above or below the starting-point, may be computed, and written in a separate column, paying particular attention to the signs. We annex an example, in which the heights are estimated in feet, and decimals of a foot.

EXAMPLE.

Station.	Distances in feet.	B. Sight.	F. Sight.	Dif. between B. S. and F. S.	Total Dif. of Level.	REMARKS.
1	650	2.35	14.55	− 12.20	− 12.20	Commenced at bench-mark *A*.
2	700	3.56	9.58	− 6.02	− 18.22	
3	750	10.34	6.21	+ 4.13	− 14.09	
4	650	14.55	0.25	+ 14.30	+ 0.21	
5	600	9.98	1.67	+ 8.31	+ 8.52	
6	650	3.62	14.54	− 10.92	− 2.40	
	B.M.	1.23	13.45	− 12.22	− 14.62	Bench-mark on rock.
7	500	2.23	12.05	− 9.82	− 24.44	Terminating at *B. M.* on oak-tree.
8	750	6.20	19.55	− 13.35	− 37.79	

The fifth column shows the difference of level between any two consecutive positions of the levelling rod, and is found by subtracting the fore-sight from the corresponding back-sight, and giving to the remainder the proper sign. The sixth column shows the distance of each point, above or below the bench-mark *A*, and is obtained by continual additions of the numbers in column 5. Thus,

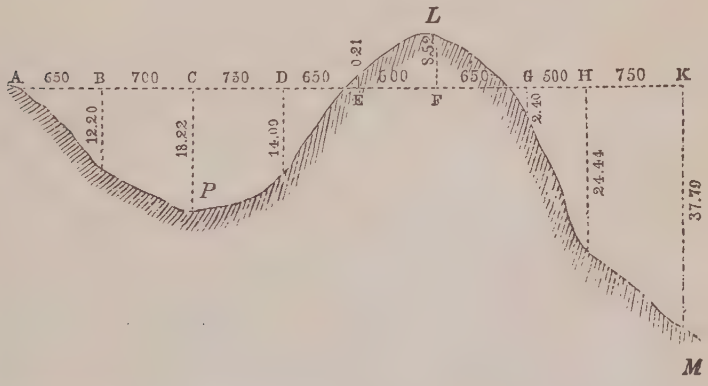
$(-12.20) + (-6.02) = -18.22$; $(-18.22) + 4.13 = -14.09$; and so on.

It will be seen that the point of termination is 37.79 feet below the starting-point.

PROFILE OF SECTION.

19. The vertical distances being generally very small as compared with the horizontal distances, two different scales become necessary in plotting a profile. In order that the vertical distances may be fully exhibited in the plan, the scale used for them is much larger than is used for the horizontal lines. This becomes absolutely necessary where long lines of profile, with a gentle slope, are to be plotted, as is always the case in the trial section of a railroad survey. We shall illustrate the manner of plotting a profile section, by drawing the section determined by the field-notes just given.

20. Draw a horizontal line *AK*, called a *datum* line, and assume some point as *A*, to represent the point of beginning: lay off, on the datum line, distances equal to the measured distances 650, 700, 750, &c., feet to *K*, using in this case a scale of 1500 feet to 1 inch. At the points *B*, *C*, *D*, *E*, &c., thus determined, erect perpendiculars, making them equal, on a scale of 25 feet to the inch, to the corresponding differences of level taken from the field-book; through the points thus found, draw the irregular line *APLM*, and it will represent the surface of the ground along the line of level.



The bench-mark, between stations 6 and 7, is not plotted, as it is supposed to be out of the line of the section, and no distances are measured to it.

SECTION II.

TOPOGRAPHICAL SURVEYING.

21. Besides the surveys that are made to determine the area of land and the relative positions of objects, it is frequently necessary to make minute and careful examinations for the purpose of ascertaining the form and accidents of the ground, and to make such a plan as will distinguish the swelling hill from the sunken valley, and the course of the rivulet from the unbroken plain.

This branch of surveying is called Topography. In surveys made with a view to the location of extensive works, the determination of the slopes and irregularities of the ground is of the first importance: indeed, the examinations would otherwise be useless.

22. The manner of ascertaining these irregularities is, to suppose the surface of the ground to be intersected by a system of horizontal planes at equal distances from each other; the curves determined by these secant planes, being lines of the surface, will indicate its form, at the places of section, and, as the planes are nearer or more distant from each other, the form of the surface will be, more or less, accurately ascertained.

If such a system of curves be determined, and then projected or let fall on a horizontal plane, it is obvious that the curves on such plane will be nearer together or farther apart, as the ascent of the hill is steep, or gentle.

If, therefore, such intersections be made, and the curves so determined be accurately delineated on paper, the map will give such a representation of the ground as will show its form, its inequalities, and its striking characteristics.

23. The subject divides itself, naturally, into two parts:

1st. To make the necessary examinations and measurements on the field; and,

2d. To make the plot, or the delineations on paper.

For the former of these objects, the theodolite is the best instrument; the common level, however, will answer all the purposes, though it is less convenient.

24. Before going on the field, it is necessary to provide a number of wooden stakes, about two feet in length, with heads. These stakes are used to designate particular points, and are to be driven to the surface of the ground. A nail should then be driven into the head of each of them, to mark its centre.

We shall, perhaps, be best understood, by giving an example or two, and then adding such general remarks as will extend the particular cases to all others that can occur.

Example First.

25. Let A, (Pl. 4, Fig. 6), be the summit of a hill, the contour of which it is required to determine and represent. At A, let a stake be driven, and let the axis of the theodolite, or level, be placed directly over the nail which marks its centre. From A, measure any line down the hill, as AB, using the telescope of the theodolite, or level, to arrange all its points in the same vertical plane. Great care must be taken to keep the measuring chain horizontal, for it is the *horizontal distances* that are required. At different points of this line, as a, b, c, d, &c., let stakes be driven, and let the horizontal distances *Aa*, *ab*, *bc*, and *cd*, be carefully measured. In placing the stakes, reference must be had to the abruptness of the declivity, and the accuracy with which the surface is to be delineated: their differences of level ought not to exceed once and a half, or twice, the distance between the horizontal planes of section.

Having placed stakes, and measured all the distances along the line *AB*, run another line down the hill, as *AC*, placing stakes at the points *e*, *f*, *g* and *h*, and measuring the horizontal distances *Ae*, *ef*, *fg*, and *gh*. Run also the line *AD*, placing stakes at *i*, *l*, *m*, and *n*, and measuring the horizontal distances *Ai*, *il*, *lm*, and *mn*.

Each line, *AB*, *AC*, *AD*, running down the hill, from *A*, may be regarded as the intersection of the hill, by a vertical plane; and these secant planes are to be continued over all the ground which is to be surveyed. If the work is done with a theodolite, or with a level having a compass, the angles *DAB* and *BAC*, contained by the vertical secant planes, can be measured; if it is done with a level, having no needle, let any of the distances *ae*, *bf*, *ai*, *bl*, &c., be measured with the chain, and there will then be known the three sides of the triangles *Aae*, *Abf*, *Aai*, *Abl*, &c.

Let, now, the difference of level of all the points marked in each of the lines *AB*, *AD*, *AC*, be determined.

In the present example the results of the measurements and levelling, are—

Line *AB*.

Distances.	Difference of Level.
Aa = 40 feet	*A* above *a* 12 feet
ab = 50 "	*a* above *b* 8 "
bc = 30 "	*b* above *c* 9 "
cd = 46 "	*c* above *d* 11 "

Line AC.

Distances.	Difference of Level.
$Ae = 28$ feet	A above e, 11 feet
$ef = 45$ "	e above f, 9 "
$fg = 55$ "	f above g, 12 "
$gh = 49$ "	g above h, 14 "

Line AD.

Distances.	Difference of Level.
$Ai = 25$ feet	A above i, 9 feet
$il = 55$ "	i above l, 13 "
$lm = 38$ "	l above m, 7 "
$mn = 48$ "	m above n, 14 "

Angle $CAB = 25°$, Angle $DAB = 30°$.

These data are sufficient, not only to find the intersections of horizontal planes with the surface of the hill, but also for delineating such curves of section on paper.

PLOT OF WORK.

Having drawn, on the paper, the line AB, lay off the angle $BAC = 25°$, and the angle $BAD = 30°$. Then, from a convenient scale of equal parts, lay off the distances Aa, ab, bc, cd, Ae, ef, fg, gh, Ai, il, lm, and mn.

Let the horizontal planes be passed at a distance of eight feet from each other. Since A is the highest point of the hill, and the difference of level of the points A and a, is 12 feet, the first plane, reckoning downwards, will intersect the line traced on the ground from A to B, between A and a. Regarding the descent as uniform, which we may do for small distances, without sensible error, we have this proportion: as the difference of level of the points A and a, is to the horizontal distance Aa, so is 8 feet, to the horizontal distance from A to where the first horizontal plane will cut the line from A to B. This distance being thus found, and laid off from A to o, gives o, a point of the curve in which the first plane intersects the ground. The points at which it cuts the line from *A* to *C*, and the line from *A* to *D*, are determined similarly, and three points in the first curve are thus found.

The graphic operations are greatly facilitated by the aid of the sector. Let it be borne in mind, that the descent from *A* to *a*, is 12 feet, and that it is required, upon the supposition of the descent being uniform, to find that part of the distance corresponding to a descent of 8 feet. Take the distance from *A* to *a*, in the dividers, and open the arms of the sector until the dividers will reach from 12 on the line of equal parts, on one side, to 12 on the line of equal parts, on the other. Then, without changing the angle, extend the dividers from 8 on one side, to 8 on the other; this will give the proportional distance to be laid off from *A* to *o*. Or, if the dividers be extended from 4 to 4, the proportional distance may be laid off from *a* to *o*.

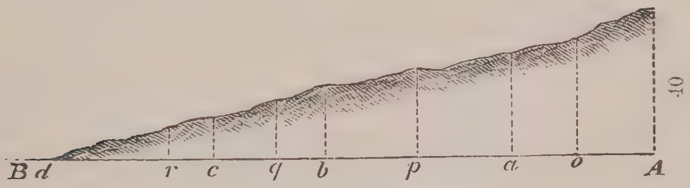
If the distances to be taken from the sector fall too near the joint, let multiples of them be used; as for instance, on the French sectors, let the arms be extended until the dividers reach from 120 on the one, to 120 on the other, then 80 or 40 will be the proportional numbers. Other multiples may be used, though it is generally more convenient to multiply by 10.

26. The second plane is to pass 8 feet below the first, that is, 16 feet below *A*, or 4 feet below *a*, *a* being 12 feet below *A*. Take the distance *ab*, in the dividers, and extend the sector, so that the dividers will reach from 8 to (the descent from *a* to *b* being 8 feet) 8, or from 80 to 80; then, the distance from 4 to 4, or from 40 to 40, being laid off from *a* to *p*, gives *p*, a point of the second curve.

The difference of level between *a* and *b*, being 8 feet, and the difference of level between *p* and *b*, must also be 4 feet; hence, the third plane will pass 4 feet below *b*, and *q*, determined as above, is a point of the third curve, and so on. After having determined the points in which each contour line cuts the lines diverging from *A*, let the contour lines be drawn through them, so as to indicate the surface of the hill. The numbers (8), (16), &c., show the vertical distances of the respective planes below the point *A*.

27. Having drawn the horizontal curves, the next thing to be done is so to shade the drawing that it may represent accurately the surface of the ground. This is done by drawing a system of small broken lines, as in the figure, perpendicular in direction to the horizontal curves already described. In all topographical representations of undulating ground, the lines of shading are drawn perpendicular to the horizontal curves.

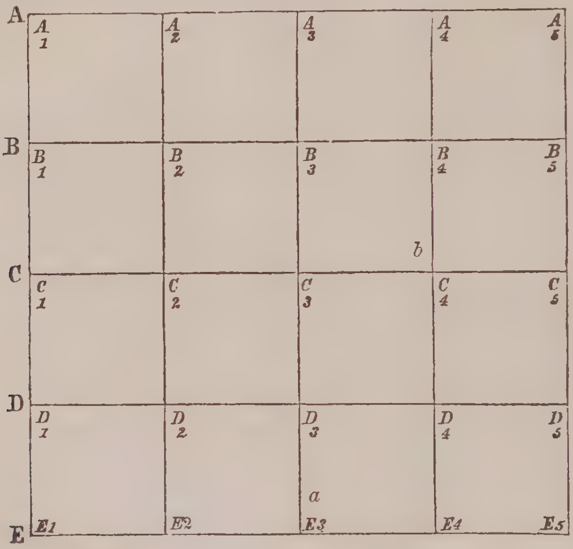
A profile along either of the diverging lines may be plotted by the rules already given (Art. **20**). The diagram shows the profile along the line *AB*.



Example Second.

28. The following example will illustrate the methods employed in making a topographical survey, where great accuracy is required.

By means of a theodolite or level, range a line of stakes *A*, *B*, *C*, *D*, *E*, &c., along one side, or through the middle of the ground to be surveyed, at equal and convenient distances from each other, say 50 feet apart. Mark, with a piece of red chalk, on each stake in this row, one of the letters of the alphabet, *A*, *B*, *C*, *D*, *E*, &c., in their order. At *A*, range a line of stakes, perpendicular to *AE*, planting the stakes at intervals of 50 feet; and mark them with the letters A_{1}, A_{2}, A_{3}, &c., which are read *A* first, *A* second, *A* third, &c.



At *B*, range a line of stakes also perpendicular to *AE*, and at distances of 50 feet from each other, and designate them B_{1}, B_{2}, B_{3}, &c. Do the same at *C*, *D*, *E*, &c., until all the stakes are placed, dividing the area, to be surveyed, into squares of 50 feet on a side. The letters and figures should be plainly marked on a smooth face of each stake, for facility of reference. If this system of notation be followed, the stakes may be recorded without danger of confusion.

The next operation is to determine the difference of level between each stake, and some fixed horizontal plane, which is called a *plane of reference*. If the sea is near, the plane of mean low water, may be taken as the plane of reference. If not, assume the horizontal plane, passing through the lowest point of the ground to be surveyed, and make a permanent bench-mark at the point of beginning. If the lowest point cannot be easily determined, assume such a plane of reference as shall pass quite below the lowest point of the ground.

The following is the form of a field-book, used in topographical levelling.

FIELD NOTES.

Back-sights.		Fore-sights.		Difference.	Total dif. of level above E 3		REMARKS.
Object.	Reading.	Object.	Reading.		Object.	Reading.	
					E3	0.000	
E3	11.432	D3	1.211	+ 10.221	D3	10.221	
		C4	0.897	+ 0.314	C4	10.535	Check 10.535
C4	11.112	E2	5.281	+ 5.831	E2	16.366	
		E4	6.154	— 0.873	E4	15.493	
		D4	6.001	+ 0.153	D4	15.646	
		D2	1.182	+ 4.819	D2	20.465	
		C3	2.917	— 1.735	C3	18.730	
		B5	6.080	— 3.163	B5	15.567	
		C5	0.921	+ 5.159	C5	20.726	
		B4	0.113	+ 0.808	B4	21.534	Check 10.999
B4	11.882	E1	8.019	+ 3.863	E1	25.397	21.534
		B3	3.990	+ 4.029	B3	29.426	
		D1	4.118	— 0.128	D1	29.298	
		C2	1.880	+ 2.238	C2	31.536	
		A4	5.000	— 3.120	A4	28.416	
		A5	9.928	— 4.928	A5	23.488	
		D5	1.675	+ 8.253	D5	31.741	
		E5	1.111	+ 0.564	E5	32.305	
		A3	0.108	+ 1.003	A3	33.308	
		C1	0.004	+ 0.104	C1	33.412	Check 11.878
C1	11.149	B2	4.181	+ 6.968	B2	40.380	33.412
		B1	2.008	+ 2.173	B1	42.553	
		A2	0.817	+ 1.191	A2	43.744	Check 10.332
							43.744
A2	10.102	A1	4.332	+ 5.570	A1	49.514	Check 5.770
							49.514

In the example, which we have taken for illustration, the stake E_3, is the lowest point, and let us assume the plane of reference to pass through that point.

Set up the level at some convenient point, as *a*, take the reading of a levelling rod, set up at E_3, (11.432), and enter this reading as a back-sight. Then take the readings of the rod, placed at as many stakes as can be reached from the position *a* of the level, entering them as fore-sights, and endeavor to make the last reading as small as possible. At this last stake, C_4, drive a small peg for a bench-mark, or check.

If we subtract the fore-sight, (D_3), (1.211), from the back-sight (E_3), (11.432), the difference, (10.221), is entered in the column headed *difference.* But this is not only the difference of level between (D_3) and (E_3), but is also the height of (D_3), (10.221), above the plane of reference through (E_3): hence, we enter this difference, under the column, headed *total diff. of level*, as well as in the column of differences for any two consecutive stations. If, now, we subtract the fore-sight (C_4), (0.897), from the fore-sight (D_3), (1.211), the difference, (0.314), is evidently the height of (C_4) above (D_3); and if we now add this difference to the previous total, (10.221), we shall have the height of (C_4) above (E_3), (10.535).

Move the level to a second point *b*, and take a back-sight to the bench-mark, $(C4)$, and fore-sights, to as many stakes as possible.

Subtracting the fore-sight (E_2), (5.281), from the back-sight (C_4), (11.112), we get the difference of level between (E_2) and (C_4), (5.831); this being added to the previous total, gives the height of (E_2) above the plane of reference, through (E_3),—namely, 16.366 feet. In subtracting the fore-sight (E_4), (6.154), from the fore-sight (E_2), (5.281), we find a negative result, (-0.873), which shows that

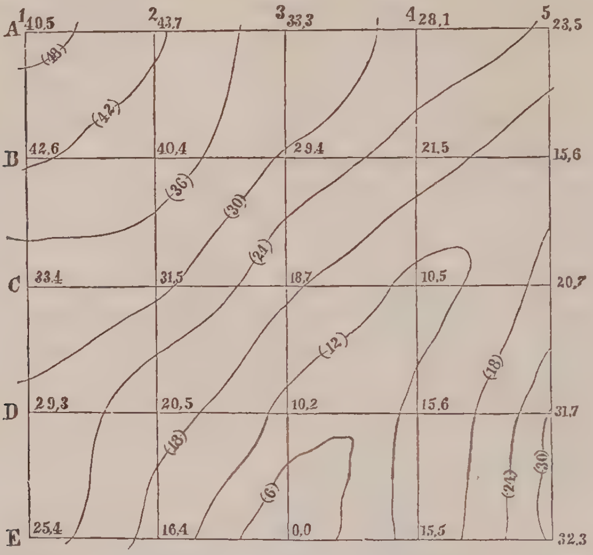
(E_4) is below (E_2). We then enter this difference, with its negative sign, in the column of differences; and to get the total, *we add it, with its algebraic sign*, to the previous total, giving (15.493), and so on, for the remaining parts of the example.

As a check on the accuracy of our computation, subtract the fore-sight (C4) from the back-sight (E3), and the difference will give the height of (C4), (10.535), above the plane of reference.

Again, subtract the fore-sight (B4) from the back-sight (C4), and add the remainder to the height of (C4), and we shall find the height of (B4), (21.534), which should agree with the height found under the heading, *total diff. of level;* and so on for each time the level is moved. Each back-sight indicates a new position of the level.

PLOTTING THE WORK.

29. Draw, on a piece of paper, a straight line AE. From a scale of equal parts, set off distances AB, BC, &c., each to represent 50 feet. Erect perpendiculars to AE, at each of the points A, B, C, &c., and then set off the distances from A to 2, from 2 to 3, &c., each to represent 50 feet; and through the points 2, 3, 4, and 5, draw parallels to AE. These, by their intersections with the lines drawn through A, B, C, &c., will determine the position of the stakes A_1, A_2, &c.; and write in red ink on the plot, the height above the plane of reference of each stake, taken from the column of total differences in the field-book. Let us suppose that the horizontal planes are to be taken at distances of 6 feet. We may find the points in which the contour lines intersect the lines at right angles, as in Example First. If only a rough plot is needed, the Surveyor may take the plot thus commenced, into the field, and by the eye trace the contour lines on the map. If we note where the lines at right angles, cut fences, roads, streams, &c., we can, by joining the points, obtain a plot of the ground.



30. The contour lines may be traced on the ground, as follows: Set up the level at *a*, and observe that the back-sight, to the stake, placed at (*E*3), gave a reading of 11.432. Depress the vane equal to the distance between the horizontal secant planes, that is, 6 feet, which is done by placing it at the reading 5.432. Then direct the rodman, by signals, up or down the hill, till the horizontal hair of the telescope coincides with the horizontal line of the vane. The foot of the staff is then 6 feet above the first point. Let a stake, marked 6, be driven here, and direct the rodman around the hill, until a second position shall be found, when the horizontal hair of the telescope will cut the vane, and drive there another stake, marked 6; and so on, until a sufficient number of stakes have been driven to determine the curve (6). Then, let the line of stakes, marked 6, be surveyed with the compass and chain, and plotted. Other contour lines may be found in a similar manner.

31. When the plane of reference is so chosen that points of the work fall on different sides of it, all the references on one side are called positive, and those on the other, negative. The curves having a negative reference are distinguished by placing the minus sign before the number; thus – ( ).

Shading and Delineation.

32. Figure 7 (Pl. 4), represents a piece of ground sloping towards *D*, which is the lowest point; and through this point the plane of reference is supposed to pass. The following table indicates the heights of the several points above the plane of reference.

		Ft.			Ft.			Ft.			Ft.
c	above	*D*, 2	*H*	above	*D*, 7	*p*	above	*D*, 9	*B*	above	*D*, 12
d	“	*D*, 4	*k*	“	*D*, 7	*q*	“	*D*, 9	*L*	“	*D*, 13
h	“	*D*, 4	*s*	“	*D*, 7	*C*	“	*D*, 9	*G*	“	*D*, 14
t	“	*D*, 4	*f*	“	*D*, 8	*n*	“	*D*, 11	*a*	“	*D*, 15
g	“	*D*, 5	*I*	“	*D*, 8	*i*	“	*D*, 12	*F*	“	*D*, 15
l	“	*D*, 5	*b*	“	*D*, 9	*m*	“	*D*, 12	*E*	“	*D*, 17

A above *D*, 20 feet.

The first horizontal plane is passed 2 feet above *D*, and the curve of intersection with the surface passes through *c*. The second secant plane is passed at 3 feet above *D*, and intersects the surface, in the curve *uv*, and also near *d*, which is one foot above the curve. All the other secant planes are passed at three feet from each other; and, comparing the height of each point above *D*, with the curves lying nearest, on either side, the positions of all the points, with respect to the curves, and with respect to each other, are easily seen.

33. The manner of shading the map, so as to indicate the hills and slopes, consists in drawing the lines of shading perpendicular to the horizontal curves, as already explained. These shading lines are drawn close together, when the slope is abrupt, and further apart, as it grows more gentle. Fig. 7 indicates the method of shading.

34. In topographical surveys, great care should be taken to leave some *permanent marks*, with their levels written on them in a durable manner. For example, if there are any rocks, let one or more of them be smoothed, and the vertical distance from the plane of reference marked thereon: or let the vertical distance of a point on some prominent building, be ascertained and marked permanently on the building. Such points should also be noted on the map, so that a person, although unacquainted with the ground, could by means of the map, go upon it, and trace out all the points, together with their differences of level.

35. Besides representing the contour of the ground, it is often necessary to make a map which shall indicate the cultivated field, the woodland, the marsh, and the winding river. For this, certain characters, or conventional signs, have been agreed upon, as the representatives of things, and when these are once fixed in the mind, they readily suggest the objects for which they stand. Those which are given in Plates 5 and 6, have been adopted by the Engineer Department, and are used in all plans and maps made by the United States Engineers.

It is very desirable that a uniform method of delineation should be adopted, and none would seem to be of higher authority than that established by the Topographical Bureau. It is, therefore, recommended, that the conventional signs given in Plates 5 and 6, be carefully studied and uniformly followed.

SECTION III.

RAILWAY CURVES.

36. The preliminary survey of a railroad establishes a succession of straight lines, of greater or less length, according to the obstacles to be avoided or the advantages to be gained, arising from the nature and the contour of the ground.

The angle formed, at each change in the direction of the route, is carefully measured and recorded.

In the final survey or location, these angles are replaced by curves; and in order that the change in direction shall be as gradual as practicable, the straight lines of direction are made tangents to the curves at their point of meeting.

The preliminary survey is termed, by the engineer, "running out tangents."

37. We will proceed to describe the method of locating curves, first giving the mathematical principles applicable to the subject.

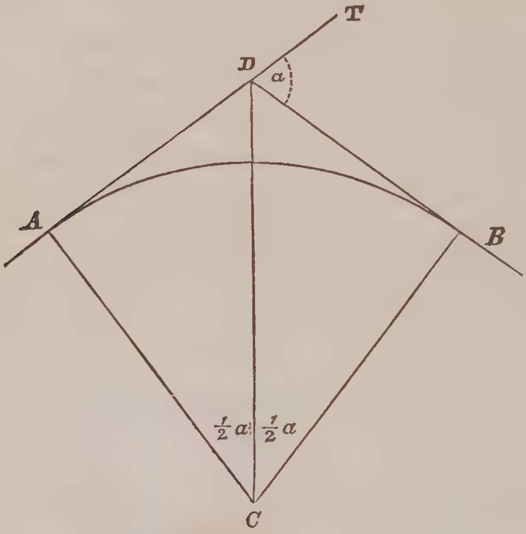
Let AD and DB (next fig.) be two tangents, to the arc of a circle, AB. Draw the radii AC, BC, and the secant CD.

The following relations are easily deduced. The tangents AD and DB are equal, (Leg., Bk. III., Prob. 14). The angles A and B are right angles (Leg., Bk. III., Prop. 9), consequently the angles C and D, of the quadrilateral $ADBC$, must be supplements of each other. The angle TDB, therefore, must be equal to the angle ACB. The right-angled triangles ADC and BDC are equal (Leg., Bk. I., Prop. 17); hence, the angle DCA is equal to DCB, and each equal to $\frac{1}{2}TDB$.

Let the radius AC be represented by r; the distance AD by d, and the angle TDB by a. Then will (Trig., Art. **66**),

$$d = r \text{ tang } \tfrac{1}{2} a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The angle TDB is the angle formed by two straight lines of the preliminary survey, and is carefully measured by the engineer, in locating tangents.



From formula (1), we can determine the value of d, for any given values of a and r; and hence we can determine, at what point on the tangent, laid off from D, the curve of any given radius must commence.

It is evident, both from the diagram and the formula, that for any given angle between the tangents, the greater the radius of the curve, the greater will be the distance cut off between the intersection of the two tangents and the point of tangency.

It is sometimes necessary to give a particular value to d. In such case, we use the formula,

$$r = d \cot \tfrac{1}{2} a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

38. The work of laying out or locating a curve in the field is somewhat simplified, if the curve have such dimensions that one chain, of 100 feet, have an arc corresponding to an exact number of degrees.

The radii of such curves are easily calculated. Thus, a circle in which one degree of arc measures one chain, will have a circumference of 360 chains, or of 36,000 feet, and consequently, a radius of $\frac{36,000}{2 \times 3.1416} = 5729.58$ feet.

In a circle in which two degrees of arc correspond to a chain, the radius will be only half as great, or 2864.79.

When three degrees of arc measure one chain, the radius is $\frac{5729.58}{3} = 1909.85$ feet.

The number of degrees corresponding to one chain, of a railway curve, is called the "*degree of curvature.*"

The radius of a one-degree curve is 5729.58 feet; of a two-degree curve, 2864.79 feet, &c.

Representing the degree of curvature by c, we have the formula,

$$r = \frac{5729.58}{c} \quad \dots\dots\dots \quad (3)$$

r being expressed in feet, and c in degrees.

Apply the preceding formulas (1), (2), (3), to the following

EXAMPLES.

1. If the angle TDB, of the tangents, be 45° 10′, what distance must be laid off from the intersection D, to the point of tangency, to admit of a 4° curve? From formula (3), we have,

$$r = \frac{5729.58}{4} = 1432.39 \text{ feet.}$$

Substituting this value of r in formula (1), we have,

$$d = 1432.39 \text{ tang } 22° \, 35' = 595.76 \text{ feet.}$$

2. If the angle a be 30°, and the distance d be 600 feet, what is the radius? *Ans.* 2239.2 feet.

3. What is the degree of curvature in the last example? Formula (3) gives

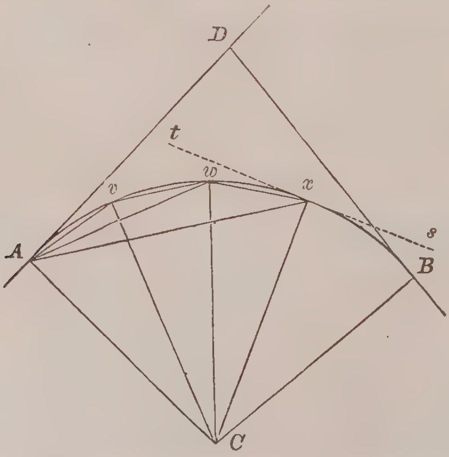
$$c = \frac{5729.58}{r} = 2.558° = 2° \; 33' \; 29''.$$

4. The angle a being 20° 21′, what is the value of d for a one-degree curve? *Ans.*

THE LOCATION OF THE CURVE.

39. The location of curves, according to the most common method, consists in laying off, at the point of tangency A, such angles as shall just subtend one chain of arc.

If the arcs Av, vw, wx, &c., represent arcs of one chain each, the angles ACv, vCw, &c., are each equal to the degree of curvature.



The angles DAv, vAw, wAx, are each equal to one-half the degree of curvature. (Leg., Bk. III., Prop. 18.)

The operations in the field are very simple. The party should consist of a transitman, two chainmen, and an axeman.

The transit is set and adjusted at a tangent point, as *A*, and directed along the tangent toward *D*.

An angle equal to half the degree of curvature is deflected from *AD* toward the side on which the curve is to run. The hind-chainman holds his end of the chain at *A*. The fore-chainman, keeping the chain carefully extended, is directed by the transitman into line with the axis of the telescope. This locates the point *v* on the curve.

From the line *Av*, another deflection is now made, of the same angle as before. The chainmen move forward; the hind-chainman stopping at *v*, while the fore-chainman, keeping the chain extended, is directed by the transitman as before, and a second stake, *w*, is fixed on the curve.

By continuing the process, of deflecting angles equal to half the degree of curvature, and causing these angles to subtend measured distances of one chain each, the entire curve is located.

The last deflection on the curve rarely corresponds to an entire chain; it is, therefore, less than the others. Its amount can be readily calculated, when it is remembered that the sum of all the deflections, or the angle *DAB*, is exactly equal to one-half the angle *a*.

It is sometimes necessary to remove the transit from the transit-point to some other point on the curve, before the location has been completed.

In such a case, the direction of the tangent to this new point should be determined. Suppose *x* to be a located point on the curve to which the transit has been transferred, and from which new points beyond *x* are to be located. Adjust the transit and direct the telescope to *A*. Lay off the angle *Axt*, equal to *DAx*, (the sum of the deflections made in locating *v*, *w*, and *x*),—*xt* is the tangent. By revolving the telescope, the tangent is produced to *s*, from which deflections may be made as at first.

NOTE 1.—The selection of the radius is governed by circumstances. Curves of the longest possible radius are, in railroads, always the most desirable; but the larger the radius for any particular pair of tangents, the greater the distance by which the curve will depart from the intersection of the tangents. It may happen, therefore, that too large a radius may lead to an obstacle, which the angle in the first survey was made to avoid.

The map, therefore, of the preliminary survey, should include so much of the topography of the adjacent section, that the radii of the curves may be selected by an inspection of the map.

NOTE 2.—It will be observed that it is the chord, and not the arc, that is measured for each deflection, when locating in the field; the difference, in railway curves, of proper dimensions, does not lead to sensible error.

For curves of a short radius (less than two thousand feet), the error may be diminished, by locating the stakes at half-chain distances, deflecting, of course, half the calculated deflection angle.

LOCATION OF CURVES BY THE CHAIN ALONE.

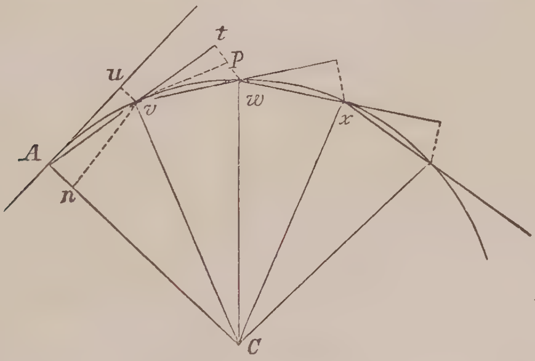
40. It is sometimes convenient to locate a curve without using the transit. In such case, the following method is generally employed.

Let A represent the point of tangency, C the centre, and v, w, x, located points of the curve, one chain apart.

From v, draw vu perpendicular to the tangent, and it will be the first offset, which denote by o. Denote the length of the chain by c, and the radius AC, by r. If, now, we suppose AC to be prolonged till it meets the circumference in some point, on the other side of the centre C, and this point then to be joined with v, and vn then drawn parallel to the tangent, we shall have, (Leg., Bk. IV., P. 23),

$$Av^2 = 2r \,.\, An\,; \quad \text{hence,} \quad o = \frac{c^2}{2r} \quad \ldots \quad (4)$$

If, now, we prolong Av, till $vt = Av$, and join t and w, tw will be the second offset, and will be double vu. For, the triangles in the figure, whose vertices are C, and whose bases are the equal chords Av, vw, &c., are isosceles and equal.



Now, in any one of the triangles, the sum of the two angles at the base and the vertical angle C, is equal to two right-angles. But, since Avt is a straight line, $tvw + wvC + CvA$, is also equal to two right-angles. Therefore, tvw is equal to any one of the equal angles at C, and is, consequently, double the angle uAv, which is half the angle C.

Since the triangle wvt is isosceles, if vp be drawn perpendicular to the base, it will bisect both the base and the vertical angle, making $tp = pw$. But the triangles Auv and vtp are equal: hence, $tw = 2vu$. Denoting the second offset by o', we have,

$$o' = \frac{c^2}{r} \quad \ldots\ldots\ldots \quad (5)$$

Hence, the practical operation consists in calculating the first offset, which is perpendicular to the tangent, by formula (4), then locating *v*, on this offset, and at a chain's distance from *A*.

Having fixed *v*, prolong *Av*, and lay off *vt* equal to one chain. Then the second, and all subsequent offsets, being double the first, we locate *w* by knowing its distances from *v* and *t*; and similarly for all other offsets.

NOTE.—In employing this method of locating curves, the aligning by which the chords are produced should be done with much care, as any error in locating a stake, involves much greater and increasing errors in succeeding stakes.

This is called, by engineers, "the method by offsetting from tangent and chords produced."

EXAMPLES.

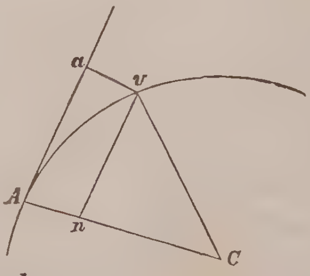
1. What are the tangent and chord offsets, for a curve of 2000 feet radius; the stakes to be 100 feet apart?

Ans. From tangent, 2.5 ft.; from chord produced, 5 ft.

2. Find offsets for a one-degree curve.

Ans. Tangent, .87 ft.; chord, 1.74 ft.

Another chain method, applicable to short curves.



41. Measure off, on the tangent, any convenient distance, as *Aa*, and offset, at right angles to this tangent, the distance *av*. If we denote the known radius of curvature by *r*, the distance measured on the tangent from *A* by *d*, and the offset *av*, by *o*, we have the formula,

$$o = r - \sqrt{r^2 - d^2} \quad . \quad . \quad . \quad . \quad (6)$$

Then, by substituting for d in the formula, different distances from A, the values of the corresponding offsets are found.

The formula is easily deduced. For, draw the radii Cv and CA, and vn parallel to the tangent Aa. Then, $nAav$ is a rectangle, and in the right-angled triangle Cvn, we have,

$$Cv^2 = Cn^2 + nv^2; \text{ or,}$$

$$r^2 = (r - o)^2 + d^2; \text{ from which}$$

$$o = r - \sqrt{r^2 - d^2} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

ANOTHER METHOD.

42. Still another method may be employed in curves where the centre is in sight from different points along the tangent. It is of use chiefly in staking out circular walks, drives, or lake borders in parks. The measurement is made along the tangent as in the last case, but the offset is measured directly toward the centre by the formula,

$$o = \sqrt{r^2 + d^2} - r \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This expression is easily verified.

EXAMPLES.

1. Find the offsets to be made at right angles to the tangent, at 50, 100, and 150 feet from the tangent point, in a curve of 1000 feet radius.

Ans. 1.25, 5.02, and 11.32.

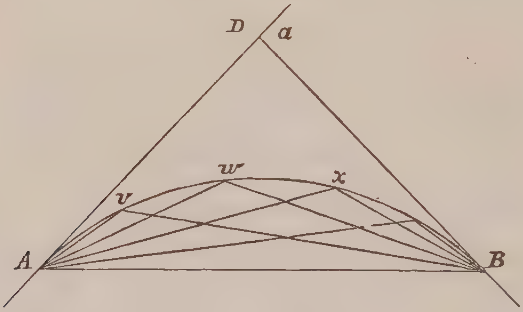
2. Find the offsets from tangent toward the centre, at 20, 40, and 60 feet on the tangent; radius being 200 feet.

Ans. .99, 3.96, 8.81 (increasing as d^2).

LOCATION OF CURVES BY TWO TRANSITS.

43. The surface over which it is necessary to locate a curve, may be of such a character as to render it impracticable for the chainmen to make their measurements; if, however, the various points are accessible to the axeman, as in the case of marshes, shallow lakes, or bays, the stakes may be accurately located by the simultaneous deflections of two transits.

The method is based on the following geometrical principle:



Let A and B be the two tangent points of the curve AvB, and D the intersection of the tangents.

If from any point v, on the curve, the lines vA, vB, be drawn, then the sum of the angles vAB and vBA is measured by one-half the arc AB, and is therefore equal to one-half the angle a, or to either of the entire angles A or B.

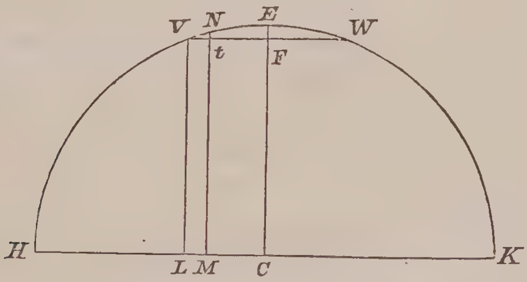
To locate the curve in the field, a transit is set at each of the tangent points A and B, and the deflection angle is determined as in the first method.

The transitman at A, deflects in the usual way, one deflection angle from the tangent AD. At the same time, the transitman at B deflects the same angle from the chord BA, or what amounts to the same, he deflects the difference between this angle and $\frac{1}{2}a$, from the tangent BD. The lines of sight of the two telescopes now intersect at a point v, on the curve, one chain from A. The flagman, directed at the same time by both transitmen, is readily brought to the location of the point. By a repetition of this process the entire curve is located.

LAYING OFF THE ORDINATES.

44. The methods described thus far for locating railway curves, apply to points 100 feet apart. This is sufficiently accurate for the earthwork. In laying the track, however, stakes every ten or twelve feet are necessary. These are set by drawing the chain or tape in a straight line between the 100-ft. stakes, and measuring from it, offsets, as often as desirable, to the intermediate points of the curve.

The length of these offsets, or ordinates, is calculated in the following manner:



Let VW represent a 100-ft. chord of a railway curve, of which C is the centre. Draw the diameter HK parallel to VW, and drop the perpendicular VL. Then, $VL^2 = HL \times LK$. (Legendre, Bk. IV., Prop. 23, cor. 2). Since $HL = r - 50$, and $LK = r + 50$, the value of VL is readily calculated for known values of the radius.

Let NM be an ordinate, at any distance from VL, say 10 feet. Then,

$$NM^2 = HM \times MK; \text{ whence,}$$
$$NM^2 = (r - 40)\ (r + 40).$$

Having determined NM, subtract VL from it, and we have Nt, one of the ordinates required.

In this manner, by calculating the full ordinate to the diameter, and subtracting VL, any desired number of offsets are determined for the half chain VF. For FW, the ordinates have the same length, but are located in the inverse order.

The middle ordinate, FE, is found by subtracting VL from the radius.

EXAMPLE.

Determined the ordinates 10 feet apart on a 100-foot chord, for a two-degree curve. Radius, 2864.79 feet.

Ans. At 10 feet . . . . = .15 feet.
At 20 " . . . . = .28 "
At 30 " . . . . = .36 "
At 40 " . . . . = .42 "
Middle ordinate . . = .43 "

SECTION IV.

SECTION LEVELLING.

45. In the surveys which precede the construction of roads, railroads, canals, dikes, or other similar earthworks, the surveyor must make such measurements as are necessary to enable him to estimate the volume of the material to be removed. In addition, therefore, to the horizontal measurements made in connection with the *location* of the work, vertical dimensions, or heights, are also necessary, and are taken at every important change in the inclination of the surface along the line of the survey.

These heights are taken by the level and rod, and are simply vertical distances of points along the surface above an assumed level line called the *datum* line.

46. In the survey of a long line of railway or canal, one of whose termini is in the vicinity of tide-water, the datum line is usually assumed at the level of mean high-water. In cases of surveys entirely inland, the datum line is taken at some convenient depth below the beginning point of the survey, and at such a distance that it shall be below the entire line on the surface. For such surveys, the system of notes described in the preceding section is insufficient.

47. As the survey progresses, fixed points of reference, called *benches*, are located in the vicinity of the line. Permanent objects are usually selected for benches; such as rocks, buildings, or trees, and at such distances from the line of the work as to be undisturbed by the subsequent construction.

48. Temporary benches, employed merely while changing the position of the levelling instrument, are called *turning points*. In either case, a well-defined point must be provided—one not easily disturbed by a blow, and, moreover, one upon which the rod can be held vertically.

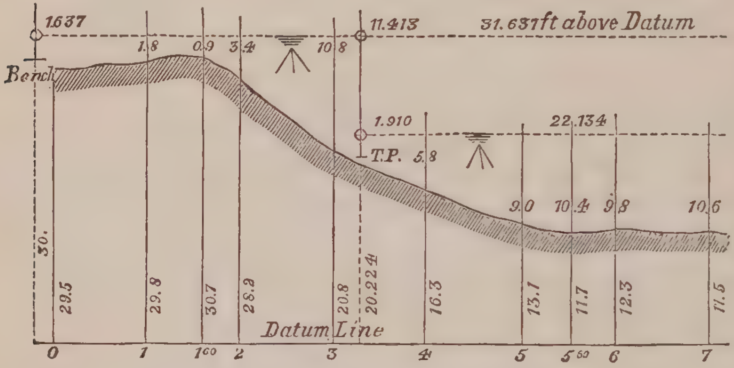
NOTE.—The order of the surveys, on a line of road or canal, after the route has been determined by *reconnoissance*, is

1st. The Transit survey, establishing the centre line of the work.

2d. The section Level, or the measurement of the profile of the centre line.

3d. The *cross-section work*, or the measurements, with the level, across the centre line, to the full width of the road, for the purpose of determining the intersection of the *slopes* with the natural surface; and also, to afford data for the estimate of the amount of earth to be removed, or filled.

49. The following example will exhibit the method of recording the notes of a section level. The datum line is assumed to be thirty feet below the first bench. When the field-book is of the ordinary pocket size, the seven columns of notes will generally occupy two opposite pages; the first five being upon the left-hand page.



Dist.	+ Sight.	Ht. of Ins.	— Sight.	Surface Height.	Grade Height.	Remarks.
Bench.	1.637	31.637		30.		Bench on top of fence -post 30 ft. north of 0 stake.
0			2.1	29.5		
1			1.8	29.8		
1^{60}			0.9	30.7		
2			3.4	28.2		
3			10.8	20.8		
T. P.	1.910	22.134	11.413	20.224		
4			5.8	16.3		
5			9.0	13.1		
5^{50}			10.4	11.7		
6			9.8	12.3		
7			10.6	11.5		

The bench having been selected and marked, its location is described in the column of remarks.

The level is adjusted in some convenient place in the vicinity, and the reading of the rod is taken upon the bench. In the above example it is 1.637. As the bench is 30 feet above the assumed datum line, the height of the instrument (or line of collimation) above this datum line is 31.637 feet.

The reading is recorded against *Bench*, in the column of + *sights*, and the "height of instrument" is recorded in its proper column, in the same line.

By referring to the above diagram it will be readily seen, that to obtain the height of the different points 0, 1, 1^{60}, &c., above the datum line, it is only necessary to take the readings of the rod, at these stations, and subtract them from 31.637. Such readings, therefore, are appropriately termed *minus sights*, and are recorded in the 4th column. As these readings are taken only to the nearest tenth of a foot, they are taken much more rapidly than the bench readings. The subtractions by which the *surface heights* are found, may be worked in the field or not, as the surveyor chooses. The unit of measurement, in the column of distances, is usually the engineer's chain of 100 feet. Readings are taken at intermediate points (as at 160 feet in the above example) when there are abrupt changes in the inclination of the surface.

50. When it becomes necessary to change the position of the level, such measures must be taken as will insure the exact "height of instrument," in the new position.

To effect this, a carefully-selected hard point is found (not necessarily on the exact line of the survey, but as far forward as convenience and accuracy will permit), and a reading of the rod is taken upon it, to thousandths.

If likely to be used for a single occasion only, it is called a "*turning-point*," and marked T. P. in the distance column; otherwise it is called a *Bench*, and its location is described in the column of remarks.

A turning-point is taken between stations 3 and 4, in the above example. The reading of the rod, upon it, is 11.413.

This is recorded in the — sight column, and the height of the point is at once found (by subtracting this reading from Height of Instrument), and recorded in the column of "Heights."

The level is next carried forward to a new position, adjusted, and directed again upon the rod at the turning-point. The reading is taken to thousandths. This, when *added* to the height of the turning-point, evidently gives the height of instrument in its new position. It is recorded, therefore, as a + sight. The survey is now continued by taking — sights at the various points along the line until it becomes again necessary to change the position of the level.

In the above example, the reading of the rod upon the turning-point, from the second position of the level, is 1.910. The height of the point upon which the rod stands is 20.224. The sum of these, or 22.134, is the "Height of Inst." for the second set of — sights. The successive subtractions of the readings from the Height of Instrument, give the surface heights as before.

The most extended section levels are but repetitions of this process.

The rules for taking and recording field-notes in section levelling are as follows:

I. *The "distances" recorded in the first column are the horizontal measurements, in chains, from the beginning of the survey to the points whose heights are to be determined. The heights are taken at each whole chain, and at such intermediate points as the irregularities of the surface require.*

II. *The first reading of the rod, after each setting of the level, is upon a bench or turning-point, and is a* "+ SIGHT:" *all other readings are* "— SIGHTS."

III. *The + sight, added to the height of the point upon which the reading was taken, gives the "Height of Instrument."*

IV. *The − sights taken, at any position of the level, subtracted from the "Height of Instrument" for that position, give the corresponding "Surface Heights."*

V. *All the +* SIGHT *readings, and the last − sight of each set, being upon benches or turning-points, are taken to thousandths of a foot. The remaining "− sights" are taken to tenths only.*

NOTE.—It will be observed that when the column of "surface heights" is complete, the second, third, and fourth columns of the field-notes are no longer needed. The first and fifth columns, which together contain the horizontal and vertical measurements for the line of work, afford all the data necessary for mapping the profile and determining the grade-line.

The location of the benches should be so described in the column of "remarks," that any particular bench may be found at any time, by referring to the field-notes. The importance of this is apparent when it is remembered that the process of construction destroys or removes the stakes along the line of the survey, and that the question of the completion of the work can be determined only by reference to the benches. It is obvious, also, that they should be established somewhat off the line of the survey. The distance apart, of regularly established benches, should be governed by the above-mentioned uses of them.

Any turning-point may be profitably made a bench (when it can be made permanent), by carefully recording, so as to admit of its identification.

In conducting a section level through a rocky district, turning-points in abundance are found at hand, and cause no delay in their preparation, whereas a bench in the same section, requires marking and *locating.*

In levelling through flat and level sections of country, although the engineer can get "sights" for long distances, a proper regard for accuracy will induce him to limit the distance, between successive positions of the level, to about six hundred feet. Under such circumstances, each turning-point is made a bench.

51. The methods of establishing benches are various. In a rocky section, some conspicuous point is marked either by drilling or grooving the rock. In villages or cities, stone steps, or projecting courses of masonry to dwellings, curb-stones, and fence-posts afford good benches, and admit of easy identification.

In sections where trees abound, a notch is cut in the side of a trunk near the root, in such a manner as to leave a projecting point upon which the rod may be held vertically. A nail driven full length into the projection, gives it the necessary firmness for a bench.

In marshes or prairies, where there are neither rocks nor trees, the engineer is compelled to resort to long stakes, firmly driven into the ground to such a depth as to be undisturbed by the frost; no portion of the stakes being allowed to project above the surface. The top of each is trimmed to a kind of blunt point, into which a nail is driven its full length.

A re-survey of a route, to detect possible errors in levelling, is accomplished by taking the heights of the "benches" only, and is called a "cheek level."

DRAWING THE PROFILE.

52. When the "section level" of a line of work has been completed, the "profile" is next to be drawn. The method of doing this is very simple.

A horizontal line to represent the *datum* line, is first drawn, and the distances from the first column of notes are laid off along it, to a convenient scale: this for ordinary working drawings is about two hundred feet to an inch.

The "surface heights" corresponding to these distances are next laid off at right angles to the datum line, and above it, but to a scale usually ten times as great as that employed for the horizontal distances; that is, an inch upon the vertical lines represents one-tenth as many feet as upon the datum line. A line joining the upper extremity of the verticals, is the profile.

By thus employing two different scales, the irregularities of the surface are made more apparent to the eye, and the subsequent adjustment of the "grade-line" is rendered much easier, and more accurate.

53. Every earthwork of importance requires, in addition to the working profiles, a general map, in which the plan drawn from the transit survey is represented upon the same sheet as the profile.

The horizontal distances of both portions of the map being drawn to the same scale, and one being placed directly above the other, corresponding points in plan and profile are readily compared.

In published maps of this kind, representing extended works, and drawn for convenience to a very small scale, the vertical scale of the profile is frequently several hundred times as great as the horizontal.

ESTABLISHMENT OF THE GRADE.

54. The determination of the height which the finished road or canal, shall have above the datum line at different points, is called "Establishing the grade."

The position and inclination of grade-lines are influenced by a variety of circumstances:

1st. The character of the work. A street admits of an inclination of five, or even eight feet in a hundred, and requires about one foot for its drainage, while a rise of two feet in a hundred upon a railroad is exceedingly rare. A canal is, of course, level, the change of height being effected by abrupt transitions at the locks.

2d. The economy of construction. It is desirable to make the earth excavated, form the required embankments, or, in the language of the engineer, "to make the cuttings balance the fillings."

It is, however, sometimes more economical to throw away, or "make a spoil bank" of the earth of an excavation, than to transport it the required distance for the embankment. Embankments, for similar reasons, are often constructed of earth obtained outside of the road limits ("borrowing pits"); or, when such means are not available, are often made of timber framing, (trestle-work).

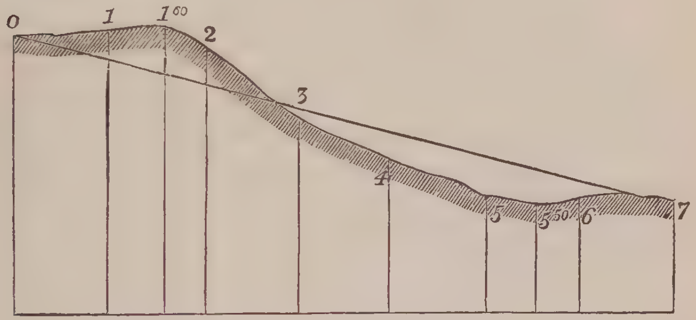
3d. The natural obstacles, which render the construction difficult; such as rocky ledges, marshes, lakes, streams, and quicksands.

In either case, the engineer determines, by inspection of the maps, at what points the grade-line shall intersect the natural surface. Thus the inclination of the grade, and, consequently, its height above the datum line, for each "distance," are easily found.

Another column of notes is now made, recording these "Grade Heights;" each being placed against the corresponding *surface height*.

The following example, with its accompanying diagram, illustrates the method of establishing a grade and recording the notes. It will be observed that the profile, with its "distances" and "surface heights," are the same as in the preceding problem.

We will suppose it is required to establish, in the following profile, a grade-line whose inclination shall not exceed 3 in 100; the grade to begin at station 0, at the surface.



Dist.	+ S.	H. of Ins.	— S.	H. of Sur.	H. of Gr.	Cut.	Fill.	Rem.
0				29.5	29.5			
1				29.8	26.8	3.0		
1^{60}				30.7	25.2	5.5		
2				28.2	24.1	4.1		0 at 2^{87}
3				20.8	21.4		0.5	
T. P.								
4				16.3	18.7		2.4	
5				13.1	16.0		2.9	
5^{50}				11.7	14.7		3.0	
6				12.3	13.3		1.0	
7				11.5				0 at 6^{92}

It is an easy matter to represent any required inclination of grade on the profile map; nothing more being necessary than to lay off the proper distances on two different verticals, and draw a line through the points of measurement. For instance: a grade of 3 in 100, running downward from station 0, would intersect the vertical at 6, eighteen feet lower, and the vertical at 7, twenty-one feet lower.

Moreover, by consulting the notes, we find that a grade-line from 0, whose height is 29.5 feet, ending at the surface at 7, whose height is 11.5 feet, descends 18 feet in 700, or 2.57 in 100.

Either of these lines would fulfil the required conditions. The first would, however, require in its construction a large excess of excavation over the embankment (as may be seen by drawing a faint line in the diagram). The second would give an excess of embankment.

It is best, generally, that the cutting should be slightly in excess, as nearly all kinds of earth shrink a little in the process of removal.

The cuttings and fillings of the profile may be balanced with tolerable accuracy, by stretching a thread across the profile so as to intersect at the 0 point, and then varying the inclination, until the areas cut off by the profile line on opposite sides of the thread appear equal.*

The column of Grade Heights must now be filled. It is easily and rapidly done. The height of Grade, at 0, is, by the conditions, 29.5. At station 1, it must be 2.7 lower, or 26.8; at 1.60, 4.3 lower, or 25.2; and at 2, 5.4 lower, or 24.1, &c.

The remaining columns of "cut" and "fill" contain simply the differences between corresponding "surface" and "grade heights." Where the surface is higher than the grade-line, the construction requires a "cutting;" when the established grade-line is higher than the surface, an embankment, or "filling," is necessary.

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* The advantage of a thread over a ruler lies in the fact, that while using the thread, the areas on both sides of it are seen at once.

In the present example, a line from 0, descending 2.7 to 100, seems to accomplish the desired purpose. The line being drawn, the "cut" and "fill" areas are measured, to determine if they are properly balanced.

The complete computation of the earthwork, by which the exact position of the grade line is determined, is explained in the next section.

The notes in the final column, indicate the points where the grade-line intersects the natural surface. Such are called zero points.

The distances are of importance in the computation of the earthwork. The above notes literally signify that either cut or fill is 0, at 2.87, also at 6.52.

These distances are obtained with sufficient accuracy for ordinary purposes by a measurement of the profile map. When the cuttings and fillings are recorded in the proper columns, the notes belonging to the section-level are complete.*

NOTE.—It will be observed that the first set of notes on page 232, did not contain the columns for cut and fill.

The practice in keeping the notes differs with the work to be performed.

In extensive railway surveys, it is convenient to rule the pages of the note-book as in the first example; carrying out the field-notes to the extent of the surface heights, at least; then transfer to another book, the "distances," "surface heights," and "grade heights," ruling columns for "cut," "fill," and "remarks."

These transferred notes are recorded in ink, and reserved for use in mapping and computations.

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* The following calculation may be employed in the more important cases. The triangles formed by the verticals (cut or fill), the grade-line, and the surface-line are similar, and give the following proportion:

The sum of the cut and fill,
: the cut,
: : the distance from cut to fill,
: distance from the cut to 0 point.

Fill may be substituted for cut in the second and fourth terms.

The application to the first zero point, in the above notes, is as follows:

4.1 + 0.6 : 4.1 : : 100 : required dist., or 87.

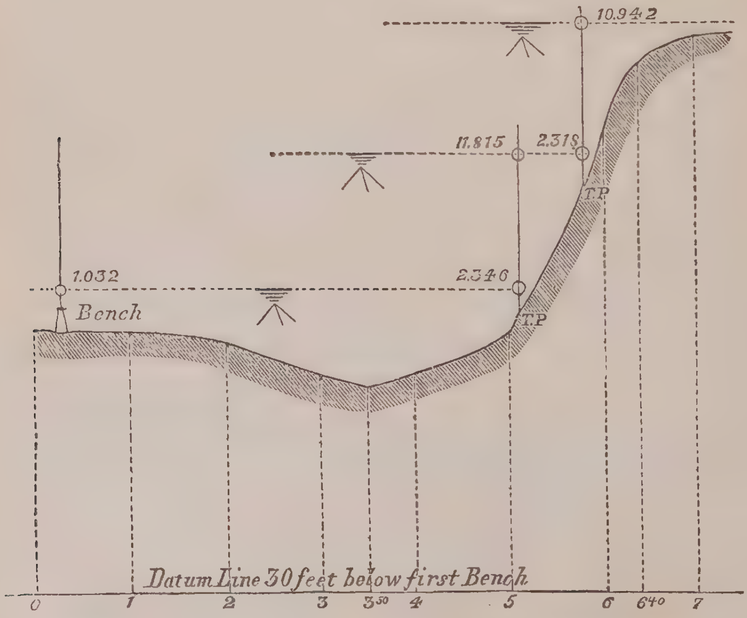
In the second case in the notes, the cut necessary to the calculation is wanting, but is easily supplied, by determining the height of grade in the usual way at station 7.

Most road or canal surveys are made on several trial-lines before one is finally adopted. The profile of each line is carefully drawn, and the cost of construction approximately estimated.

When the route is finally selected, and the section levels satisfactorily completed, the exact width of the earthwork, both in excavations and embankments, is carefully staked out and the amount of material to be moved in the progress of construction, accurately measured.

The method of conducting this work is explained in the next section.

Before closing the subject of section levelling, we will consider the profile represented in the figure, and the set of field-notes appended, which are only partially completed, and which will afford some examples for practice.



Dist.	+ S.	Ht. of Ins.	— S.	Surface Heights.	REMARKS.
Bench.	1.032				
0			3.2		
1			3.8		
2			5.3		
3			8.9		
3^{50}			10.3		
4			9.0		
5			4.8		
T. P.	11.815		2.346		
T. P.	10.942		2.318		
6			9.7		
6^{40}			6.4		
7			2.1		

1. What is the "Height of Instrument" for the first position of the level? *Ans.* 31.032.

2. What is the height of the first T. P.? *Ans.* 28.686.

3. What is the "Ht. of Inst." for the second position of the level? *Ans.* 40.501.

4. What is the height of the second T. P.? *Ans.* 38.183.

5. What is the "Ht. of Inst." for the third position of the level? *Ans.* 49.125.

6. What is the Height of Surface at 0? *Ans.* 27.8.
7. " " " " at 3? " 22.1.
8. " " " " at 3^{50}? " 20.7.
9. " " " " at 5? " 26.2.
10. " " " " at 6? " 39.4.
at 7? " 47.0.

11. Write the "Surface Heights" for the distances 1, 2, 4, and 6^{40}.

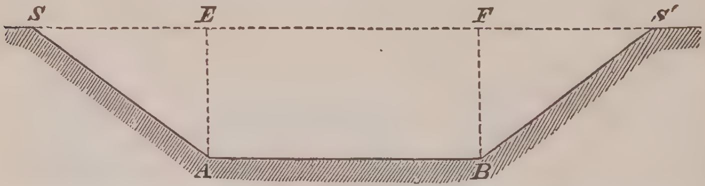
Cross-Section Levelling.

55. All earthworks, whether excavation or embankment, unless held in position by retaining walls, require to be constructed with a sloping surface, the inclination of which depends upon the kind of earth.

If, in a railway-cutting, for instance, the banks which bound it be left too nearly vertical, when first constructed, the weathering influences, to which they are subjected, soon cause the material to slide down, until the whole slope gradually assumes a much lower inclination.

After a time, however, the tendency to roll or slide is checked by the friction of the particles themselves, and the slope thus formed will withstand the ordinary effects of sun, wind, and rain. The inclination thus assumed is called the "natural slope" of that kind of earth.*

Slopes are expressed mathematically by the ratio of their horizontal to their vertical dimensions, and which is called the *ratio of slope.*



In the diagram, which represents a road-cutting, the ratio of ES to AE, or of FS' to BF, is the ratio of slope.

In practice, the slope at which earthworks are allowed to stand, vary from 1 to 1, or 45°, (as in very coarse material); to 2 to 1, or 26° 34′, in very fine sand.

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* This slope is determined, experimentally, by drying a portion of the earth, and then pouring it from a slight elevation upon a level surface. The heap thus formed is a rather flat cone, whose sides stand at the lowest inclination they would be liable to assume under the action of atmospheric influences. The angle with the horizontal plane will be somewhere between 25° and 45°.

A slope of $1\frac{1}{2}$ to 1, (33° 41′), is found to be so far suitable for all ordinary excavations or embankments, that it is common, in the absence of an examination of the material, to adopt it as the ratio of slope throughout.

SETTING SLOPE STAKES.

56. It is evident that the width of natural surface of ground, required in the construction of a road, will vary with the depth of excavation or embankment.

As often, therefore, as it is found necessary to determine the depth of the cutting or filling, in the section level, it is also necessary to mark the boundaries of the width of the work, on the natural surface. This is done by stakes called *Slope Stakes*, and the field-work necessary to determine their position, and to measure the section taken across the road, of which the Slope Stakes indicate the boundaries, is called "Cross-Section Levelling," or "Cross-Section Work."

57. A party of five may be usefully employed in setting Slope Stakes; viz., a leveller, rodman, axeman, and two tape-men.

The rod, for Cross-Section work, is a ruder instrument than that employed in the Section level. It should be at least fifteen feet long, with the feet and tenths plainly marked. It requires no target, the leveller himself reading the rod in the act of sighting.

The field-book is ruled as shown below.

Dist.	Left.	Centre cuttings.	Right.

The left-hand column contains the distances taken from the Section-level notes. The third column is for the cut or fill, corresponding to the distance in the first column; these numbers also being taken from the notes of the section level.

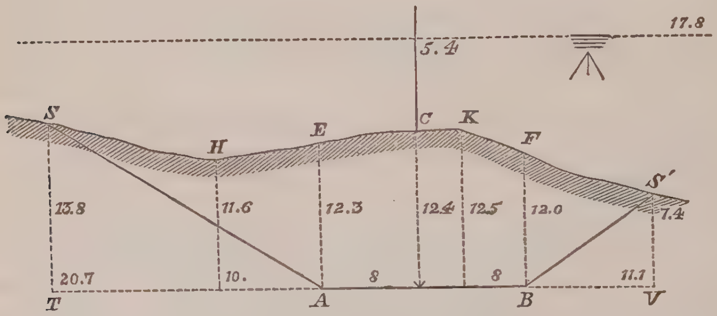
A *filling*, it should be remarked here, is designated as a *minus cutting* in the field-notes.

The second and fourth columns are for the horizontal and vertical measurements of the cross section.

The examples following will illustrate the method of measuring the section and recording the notes.

Let figure represent a section across a road excavation. *AB* being the bed of the road, and *SCS′* the line of the natural surface.

The road-bed is supposed to be 16 feet wide, the centre cutting 12.4 feet, and the ratio of slope 1½ to 1.



The level being set up and adjusted in a convenient place, the rod is first held by the centre stake at *C*, and a reading taken.

In the present example, the reading is 5.4. The line *AB* forms a convenient datum line, and the height of the instrument above this line, is evidently 12.4 + 5.4 = 17.8 ft.

This is noted down, for the moment, on a reserved page of the note-book, or on a spare slip of paper; neither the height of instrument or rod readings being matters of permanent record in cross-section work.

It is evident that if the rod be held at different points along the surface, and the readings subtracted from the "height of instrument," the remainders will be the heights of these points above the datum line *AB*. These heights are technically called *cuttings*, although in the case of *ST* and *S′V*, no actual excavation is proposed.

The reading at *E* is supposed to be 5.5. The cut is therefore 12.3. The horizontal distance from the centre is 8 feet. For each cutting there will be a horizontal measurement, and these two must be recorded together.

The form adopted is that of a fraction in which the numerator is the cutting and the denominator the distance.

The record of this measurement would be, therefore, $\frac{12.3}{8}$, in the column marked "left." The points *A* and *B*, of the cross section are appropriately termed the *angles*, and as the points *E* and *F*, directly over them, become new starting-points for horizontal measurements, it is important to distinguish them, in some way, in the notes.

(Right and left in the actual survey are determined by the direction in which the survey progresses, and in which the centre stakes are numbered.)

A common method is the one adopted in our notes—to substitute for the number which represents the half width of the road, the letter *A*.

The hind-chainman now takes his position at *E*, and the remaining distances to the left are measured from this point.

A change in the surface-line at *H* requires notice. The reading of the rod 6.2 indicates a cut of 11.6. This, with the distance from *E*, 10 feet, is duly recorded.

There being no other material change in the surface line beyond *H*, there remains to be determined on this side only the intersection *S*, of the surface and slope.

It is found by trial. When found, it is evident that the ratio of the distance to the "cut," must be the same as the ratio of slope. In the present example, the distance must be 1½ times the cut.

Suppose a trial reading taken at 25 feet out, is 3.2. The height, or cut, is (17.8 − 3.2) = 14.6. 1½ times this is only 21.9 feet. The distance tried, 25 feet, is too great.

Suppose a second trial at 22 feet out, with a rod reading of 3.8. The cut is 14. 1½ times this is 21. Still too far out.

A third trial, at 21 feet out, and a reading of 4, gives a cut of 13.8 ft. This multiplied by 1½ gives 20.7 feet. The measured distance is slightly too great, but in ordinary practice this approximation would be considered near enough. The record for the slope-stake *S* would therefore be $\frac{13.8}{20.7}$.*

In proceeding from the centre to the right, we find a point *K* between the centre and the angle, that requires attention.

The distance in such a case is taken from the centre instead of the angle. *CK* is 3 ft. and the rod reading 5.3 gives a cut of 12.5. The reading at the angle-stake *F* is 5.8, giving a cut of 12 feet.

If the surface-line from *F* were level, the distance *FS'* would be 12 × 1½ = 18 feet; but as the ground descends, the distance is less.

A trial at 11 ft. with a reading of the rod of 10.4, indicates a cut of 7.4. This multiplied by 1½ gives 11.1, which is very nearly right: $\frac{7.4}{11.1}$ is therefore the record for the location of *S'*.

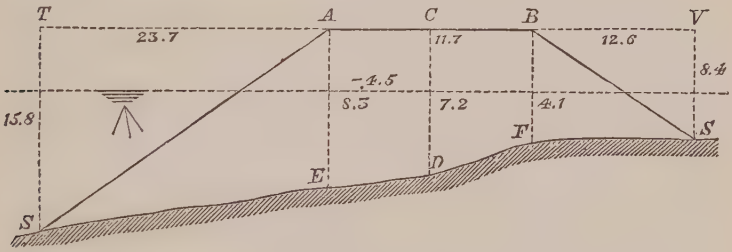
---

* The readings and distances in this example have been made to correspond to a rise of one foot in five from *H* to *S*. The exact record for *S* is $\frac{13.72}{20.58}$.

The completed notes for this cross section are as follows:

Dist.	Left.			Centre Cut.	Right.		
——	$\frac{13.8}{20.7}$	$\frac{11.6}{10}$	$\frac{12.3}{A}$	12.4	$\frac{12.5}{3}$	$\frac{12}{A}$	$\frac{7.4}{11.1}$

58. We will now give a similar example, illustrating the method of staking out embankments.



Dist.	Left.		Centre Cut.	Right.	
——	$\frac{-15.8}{23.7}$	$\frac{-12.8}{A}$	− 11.7	$\frac{-8.6}{A}$	$\frac{-8.4}{12.6}$

The filling at the centre is assumed to be 11.7 ft., which appears in the column of "centre cut," with its appropriate sign.

The reading of the rod, at the centre, as shown by the diagram, is 7.2.

The sum of the reading and the centre cut, (7.2 − 11.7), is − 4.5, which is the "height of instrument" referred to the line *AB*.

The readings at all other points along the line *SS*′, must be subtracted from this "height of instrument," as in the preceding example. The several remainders are the corresponding "cuttings."

The reading at angle stake *E*, 8.3, subtracted from − 4.5, gives − 12.8, for the cut.

For the slope stake *S*, we will suppose a trial distance of 20 feet from *E*, and a rod reading at the trial point of 10.8 feet. The cut is therefore, − 15.3; this multiplied by $1\frac{1}{2}$ gives 22.95.* The trial distance therefore, 20 feet, is not enough.

A trial of 24 feet out, we will suppose to give a rod reading of 11.3 ft., which corresponds to a cut of − 15.8 ft. The ratio applied to this, gives for the proper corresponding distance out, 23.7 ft., which is nearly correct. The distance at which the trial was made is slightly too great. It is evident that if the slope stake be set at the calculated distance, 23.7 ft., the record of $\frac{-15.8}{23.7}$ may be made without involving an error of more than a tenth of a foot, in either cut or distance.

On the right, the reading at the angle stake *F*, is 4.1. The cut, therefore, is − 8.6 feet.

As the surface rises but little from *F* to *S′*, the trial distance for the slope stake is taken at 12 feet; (it should be 12.9 ft., if the surface were level): the reading is supposed to be 3.9 feet. This gives the cut − 8.4, which should correspond to a distance out of 12.6 feet. It is evident, that considering the rise in the surface and the rod readings at *F* and *S′*, the rod reading at *S′* would not vary a tenth if moved from 12 feet to 12.6. The record, therefore, for *S′* is $\frac{-8.4}{12.6}$

59 The rules for conducting and recording cross-section work, whether for excavation or embankment, are as follows:

I. *Prepare the field-book by ruling columns for Distances*

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[*] The sign is disregarded in the product. It may be well to notice, however, that the ratio of slope in embankments is considered to be $1\frac{1}{2}$ to − 1.

and Centre Cuttings, leaving wider spaces on either side of the latter column for the record of the various measurements to the left and right of the centre stake. Transfer from the section-level notes the distances and corresponding cut or fill, for each stake of that survey. Filling in the cross-section notes is designated as minus *cutting.*

II. *Having set the level in convenient proximity to a proposed cross section, take a reading of the rod at the centre stake. Add this reading to the centre cutting, (regarding the sign of the latter), to obtain the "height of instrument."*

III. *Lay off half the width of the road-bed each side of the centre, and mark the distances, temporarily, with stakes. These are the angle stakes.*

IV. *Proceed to take rod readings at the angle stakes, and beyond them outward, (on a line at right angles to the direction of the line of the road), at each change of inclination of the surface. Subtract each reading from the height of instrument; the remainder is the cutting, or vertical distance of the point measured, from the proposed road-bed.*

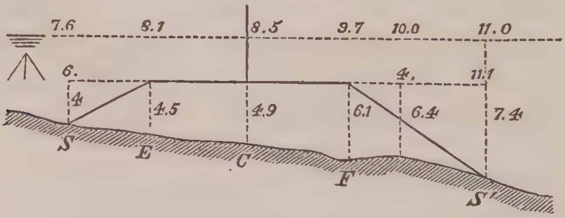
V. *Record each cutting, together with its horizontal distance from the nearest angle stake, in the form of a fraction expressing the ratio of the distance to the cutting. Each fraction being recorded in its proper column either "right" or "left" of the centre. Points between the centre and angle stake, are located by measurements from the centre.*

VI. *To find the position of the slope stake: Measure off a trial distance from the angle stake, and determine the cut as before. Multiply the cut by the ratio of height to base of the proposed slope. If the trial distance be greater than this product, the assumed point is too far out, and vice versa. Repeat the* *trial until the ratio of the distance to the cut expresses the ratio of slope.*

60. The cutting at the angle stake is, in cases of a tolerably uniform surface, a good guide to the distance to the slope stake. Thus, when the angle cutting of an excavation is 16 feet and the ratio of slope 1½ to 1, the distance out, for a level surface, would be 24 feet; but if the ground in that distance rise 2 feet, (and which in practice may be determined pretty correctly by the eye), then the horizontal distance must be increased by something more than 1½ times 2 feet.

When the surface descends, the estimated distance out, for a level surface, should in like manner be diminished. In embankments the conditions are reversed; the steeper the rise, the shorter the distance out.

61. The following examples will serve to elucidate the subject still further.



Dist.	Left.	Centre Cut.	Right.
———	$-\frac{4.}{6.}$ $-\frac{4.5}{A}$	$-$ 4.9	$-\frac{6.1}{A}$ $-\frac{6.4}{4}$ $-\frac{7.4}{11.1}$

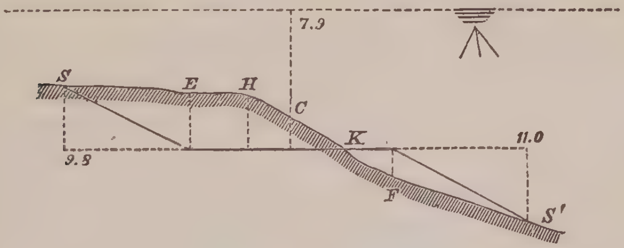
The diagram represents an embankment cross section, in which, by reason of the small depth of filling, the height of instrument is a positive quantity.

The centre cut is -4.9; reading of the rod at the centre, 8.5; the sum of these, or "height of instrument," is 3.6. The remaining rod readings are given on the line through the instrument.

62. In the example of the following diagram, the cross section is partly in excavation and partly in embankment. The ratio of slope is 2 to 1. The centre cut is 2.4. The centre reading is 7.9; height of instrument, 10.3.

The reading at *H*, is 6.3; at *E*, 6.1; at *S*, 5.4. The point, *K*, is easily found in practice, it being that point on the surface-line where the reading of the rod exactly equals the height of instrument. The reading at *F* is 13.2; and at *S'*, 15.8.

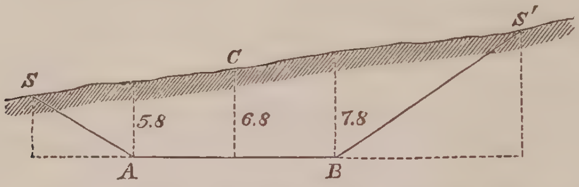
From these readings the cuttings may be found, and the notes completed as below.



Dist.	Left.			Centre Cut.	Right.		
——	$\frac{4.9}{9.8}$	$\frac{4.2}{A}$	$\frac{4.0}{3.8}$	2.4	$\frac{0}{.4}$	$\frac{-2.9}{A}$	$\frac{-5.5}{11}$

63. In the following example, there is a regular rise in the surface-line of one foot in eight. The ratio of slope in the excavation is to be $1\frac{1}{2}$ to 1; height of instrument, 14.2.

In seeking for the position of the slope-stake *S'*, a distance out of 13 feet is tried; the reading of the rod at the trial point is 4.8.



How does this point compare with the true position of S'?

Ans. Not far enough out.

What is the result of a trial at 16 feet out and a reading of 4.4? *Ans.* Too far out.

What is the true cut and distance at S'? *Ans.* $\frac{9.6}{14.4}$

Find the position of S. *Ans.* $\frac{4.9}{7.3}+$

NOTE 1.—It sometimes happens, in very hilly sections, that it is impracticable to sight to all the necessary points of a single cross section from one position of the level. In such a case, it is only necessary to work from the centre as far as the surface will permit, then establish a turning-point, precisely as in section levelling; change the position of the level so as to proceed with the work, and determine the new height of instrument, from which the readings are to be subtracted as before.

NOTE 2.—The degree of accuracy desirable to be attained in setting the slope stake, varies with the kind of earth to be "staked out," so that no exact rule can be laid down.

A principle, in quite general use, permits the stake to be set when the calculated distance varies from the trial distance by less than a foot.

The limit of error should never be greater than this, but in rock and the harder kinds of earthwork, it should be made much less.

COMPUTATION OF EARTHWORK.

64. Before the work of construction of a railroad or canal commences, the calculation of the earthwork must be completed.

The cross-section levels afford the necessary data. These surveys have divided the proposed work into blocks of 100 feet, or less, in length, and which are appropriately termed prismoids. Different methods are employed for estimating their cubic contents. The most accurate, though the most laborious, is the prismoidal formula, (Leg., Mensuration, page 129),

$$\text{vol.} = \frac{l}{6}\,(B + B' + 4M)$$

B and B' representing the areas of the end sections of the prismoid, M the area of a section midway between them, and l the entire length of the solid.

The principal difficulty in applying this formula lies in finding the dimensions of the middle section.

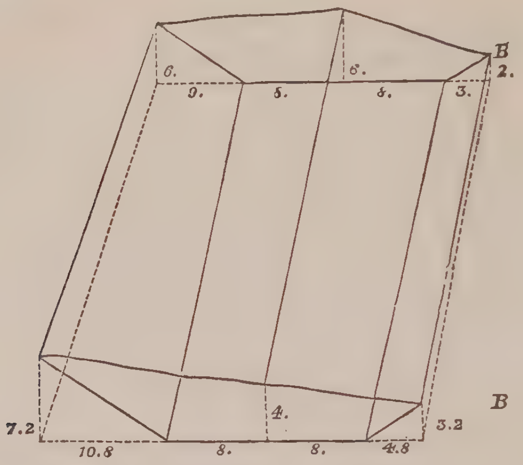
We will show the application of the formula by an example of road excavation.

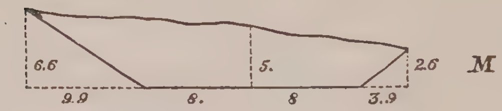
To simplify the problem, we will suppose such a degree of regularity in the ground surface that the angle cuttings may be omitted.

The length is supposed to be 100 feet. The other dimensions are given in the diagram.

The areas of the end sections are easily found. It is only necessary, in each case, to add together the areas of the trapezoids composing the whole end figure, as represented in the diagram, and subtract therefrom the sum of the triangles which lie outside the section. The dimensions of these triangles are always expressed in the cross-section notes, by the records for the slope stakes.

The area of B is thus found to be 104.8 sq. feet, and of B', 116 sq. feet.





Now, if a section of this prismoid be taken midway between the two ends, each of its several dimensions must be an arithmetical mean of the corresponding measurements of the end sections. Thus, the centre cutting is found to be 5 ft.; the distance from the angle to slope stake, on the left, 9.9 ft., $\left(\frac{10.8 + 9}{2}\right)$; the cutting on the extreme left is 6.6 ft., $\left(\frac{7.2 + 6}{2}\right)$ &c.

The area of M is 111.3 sq. ft.

$$\text{Vol. of the prismoid} = \frac{1}{6} \times 100 \ (104.8 + 116 + 445.2),$$
$$= 11100 \text{ cubic feet.}$$

65. Two other methods of computation are of frequent use among engineers. They are less laborious than the prismoidal rule, but they are also less accurate.

The first is known as the "Arithmetical Average" method. The rule is:

Multiply half the sum of the end areas by the length of the prismoid.

Applied to the example just solved, we should have,

$$\text{vol.} = 100 \times \frac{104.8 + 116.}{2} = 11040 \text{ cu. ft.}$$

66. The other method is called the "Mean Average" method. The rule is expressed thus:

Add together the two end areas and their geometrical mean proportional. Multiply this sum by one-third of the length of the prismoid.

This method, applied to the example, gives for the volume:

$$\begin{aligned}\text{vol.} &= \frac{1}{3} \times 100 \ (104.8 + 116 + \sqrt{104.8 \times 116}) \\ &= 11035 \text{ cubic feet.}\end{aligned}$$

NOTE.—When the difference between the end areas is considerable, the mean average method gives better results than the method of arithmetical average.

The last mentioned rule has been largely employed by the engineers of the public works of the State of New York.

Tables based upon the prismoidal formula, or modifications of it, are much used by engineers in earthwork computations.

67. In applying the prismoidal formula to an example in which one end section has more given dimensions than the other, the calculator is frequently in doubt how he shall average these dimensions to obtain the middle section. As a rule, each cutting of the most irregular section should be averaged with the cutting nearest opposite to it, in the other section.

We will illustrate this by a final example of earthwork: representing the sections by the field-notes only.

Dist.	Left.			Centre cut.	Right.		
2	$\frac{17.2}{25.8}$	$\frac{16.8}{A}$	$\frac{16}{2}$	15.8	$\frac{13}{A}$	$\frac{10}{8}$	$\frac{8.4}{12.6}$
2.60	$\frac{11.6}{17.4}$	$\frac{11.2}{A}$		10.4	$\frac{10}{A}$	$\frac{8}{12}$	

The half-width of the road, for which *A* is given in the notes, is to be considered as 8 feet. The length of the prismoid is expressed by the difference of the given distances, or 60 feet.

The dimensions of the middle section are found as follows:

The centre cut is half the sum of the given similar dimensions, $\frac{15.8+10.4}{2} = 13.1$ feet.

On the right, the average of the angle cuttings gives $\frac{11.5}{A}$; for the next measurement, both cut and distance must be averaged; it is,

$$\begin{array}{l} \frac{1}{2} \times (10+8) = 9 \\ \frac{1}{2} \times (8+12) = 10 \end{array} \quad \text{or,} \quad \frac{9}{10}.$$

The last term in the upper section must be averaged with the last in the lower, thus:

$$\begin{array}{l} \frac{1}{2} \times (\ 8+\ 8.4) = \ 8.2 \\ \frac{1}{2} \times (12+12.6) = 12.3 \end{array} \quad \text{or,} \quad \frac{8.2}{12.3}.$$

On the left, the measurement $\frac{16}{2}$ of the upper section, must be averaged with the centre cutting of the lower, being nearest opposite to that point. We have,

$$\begin{array}{l} \frac{1}{2} \times (16+10.4) = 13.2 \\ \frac{1}{2} \times (\ 2+\ 0\ ) = 1 \end{array} \quad \text{or,} \quad \frac{13.2}{1}$$

At the angle, in like manner, we have $\frac{14}{A}$; and finally at the slope stake $\frac{14.4}{21.6}$. The complete dimensions being

$$\frac{14.4}{21.6} \quad \frac{14}{A} \quad \frac{13.2}{1} \quad \left| \; 13.1 \; \right| \quad \frac{11.5}{A} \quad \frac{9}{10} \quad \frac{8.2}{12.3}.$$

The area of the upper section, after subtracting the triangles, as before, is 543.47 sq. feet.

The area of the lower end section is 325.44.

The middle section contains 429.8 sq. feet.

The volume of the prismoid is

$$\tfrac{1}{6} \times 60(543.47 + 325.44 + 4 \times 429.8)$$
$$= 25881.1 \text{ cubic feet, or } 958.56 \text{ cubic yards.}$$

SECTION V.

MINING SURVEYING.

Definitions and general Notions.

68. MINING SURVEYING comprises all the operations necessary to determine the relative positions of the parts of a mine with respect to each other, and also, with respect to the surface of the earth.

69. The general principles involved in this branch of surveying are the same as those used in surface surveying, but, from the nature of the case, certain modifications are required, both in the instruments employed and in the manner of using them.

Stations are designated by lamps instead of flags, and lamp-stands instead of flag-rods; *station points*, if temporary, are marked by cross lines chipped in the rock, or sometimes by simple chalk lines, and, if permanent, by iron pegs driven into holes drilled for the purpose. *Lines* are measured along the slope, instead of on the horizontal, the chainmen being guided by lamps instead of rods. *Angles* are measured by instruments specially devised for underground use; the *compass*, when used, is generally of a widely different form from the ordinary surveyor's compass; the *theodolite*, which is the principal angular instrument employed, differs from the ordinary theodolite in having a diagonal eye-piece, to permit observations to be made when the telescope is directed vertically upward, and also an arrangement for illuminating the cross hairs. These modifications will be more fully described in a subsequent article.

Traversing.

70. TRAVERSING is the operation of running a zig-zag line, from one point to another. The elements of the traverse are straight lines, determined by their lengths and by their inclinations to certain fixed planes. In mining surveying, three such planes are used; the *first*, is either a meridian plane through the origin of the traverse, or a vertical plane through the first course; the *second*, is a horizontal plane through the origin; and the *third*, is a vertical plane through the origin, and perpendicular to the other two.

71. WORKING, OR REDUCING THE TRAVERSE, is the operation of finding the length and direction of a single line, equivalent to the zig-zag, that is, starting from, and terminating at, the same points. Such a line is called the *resultant* of the traverse.

The zig-zag line is run along the subterranean openings of a mine. For the sake of uniformity, such openings, when vertical, will be called *shafts*, and when not vertical, *galleries*.

Method of traversing with the Compass and Semicircle.

72. In running a subterranean traverse with the magnetic needle, a form of compass is used, called the *Miner's Compass.* It consists of a compass-box like that of the Surveyor's Compass, except that the graduation extends from 0° around, by the left, to 360°. This box is weighted at the bottom, and mounted on a universal joint, like the Mariner's Compass. The ring that supports the universal joint is provided with hooks for suspending it from a wire stretched along the gallery. When so suspended, the box assumes a horizontal position, the diameter through the 0 point of the graduated circle falling immediately under the wire; if the compass be so suspended that the 0 end of this diameter points backward, and the 180° end in the direction the traverse is being run, the reading at the *north end* of the needle is the angular distance from the *north point,* around by the east to the direction of the course: this angle is called the *Azimuth of the Course.*

Miner's Semicircle.

73. The *slope* of the Course is measured by the *Miner's Semicircle.* This is a graduated semicircle, with hooks, for suspending it from a stretched wire, and a plumb-line attached at the centre of the circle. When suspended, the plane of the semicircle is vertical, and its diameter is parallel to the wire; the 0 point of the graduation is at the extremity of the radius which is perpendicular to the wire, and, as the divisions are numbered both ways, the reading of the plumb-line gives the slope. As it is impossible to stretch a wire so that it shall be perfectly straight, the slope measured at different points will not be the same; a fair result will be obtained by measuring the slope at each end of the wire, and taking the average as the true slope.

74. To run a traverse, with the compass and semicircle, a copper wire is stretched from the place of beginning, say at the bottom of the shaft, to some convenient point of the gallery, and both ends made fast to iron hooks, driven into the walls of the gallery; the compass is suspended from this, at some point near its middle, and after it comes to rest, the azimuth of the course is read off and recorded; the semicircle is then suspended, first, near one end of the wire and then near the other, and the average reading is recorded, care being taken to note whether the slope is in *elevation* or *depression;* the length of the wire, from hook to hook, is then measured and entered in the field-book. If necessary, measurements are made to determine the cross section of the gallery, at any desired point of the course, and the results entered in the column of remarks. The wire is then detached from the hooks and carried forward along the gallery, one end being made fast at the extremity of the first course, and the other at some convenient point, generally on the opposite side of the gallery; the same measurements are made as before and recorded under the proper headings, and so on, to the end of the traverse. The method of entering the *field-notes,* is shown in the following

FIELD BOOK.

Course.	Slope.		Azimuth.	Length in feet.	REMARKS.
	Elevation.	Depression.			
1	——	2° 30′	203°	307	Stat. 1, at iron peg, centre of shaft.
2	——	3° 15′	199° 15′	402	
3	——	3° 30′	251° 30′	240	
4	——	4° 15′	300° 00′	367	
5	1° 30′	——	269° 15′	409	
6	2° 00′	——	272° 45′	200	At iron peg.

Method of Traversing with the Theodolite.

75. In traversing with the theodolite, it becomes necessary to illuminate the cross hairs of the diaphragm. This is accomplished by a diagonal mirror, placed in front of the object-lens of the telescope. The mirror is supported by a stem projecting from a ring that surrounds the tube of the telescope, and has an opening in the prolongation of the tube, so as not to intercept the rays of light from the object. A lamp, placed on one side of the theodolite, illuminates the remainder of the mirror, and, if properly situated, a portion of its light is reflected into the tube of the telescope and thrown on the cross hairs. Sometimes the theodolite is furnished with three tripods exactly alike, upon each of which the instrument is mounted in turn, the other two serving to support the guiding lamps, which are so constructed that the flame of the lamp shall be as far above the top of the tripod as the axis of the vertical limb. Sometimes a single tripod is used, in which case the guiding lamps are placed on stands similar to the tripods, but with sliding pieces carrying the lamps, and fixed in position by clamp-screws. By this arrangement, the height of the lamp may be made equal to that of the theodolite. The lamps are protected by glass shades, of any color that may be desired.

To run a Traverse with a Theodolite having three Tripods.

76. Select a place for the first station, say at the foot of the shaft, and mark it permanently; set up a tripod over it, and place a station lamp on it: select a second station at some suitable point, generally at a turn in the gallery, set up a tripod over it, and on it put the theodolite: at the third station, still further along the gallery, set up the third tripod, and on it put a station lamp. The theodolite being levelled and the horizontal limb clamped, direct the telescope to the lamp at the first station, and read both limbs; the reading of the vertical limb will be the slope of the first course, in *elevation,* if the telescope point downward—in *depression,* if it point upward; then unclamp the vernier plate. and direct the telescope to the lamp at the third station, reading both limbs as before; the reading of the vertical limb will be the slope of the second course, in *elevation,* if the telescope point upward—in *depression,* if it point downward; subtract the first reading on the horizontal limb from the second (the latter increased by 360° if the 0 of the vernier has passed the 0 of the limb), and the difference will be the horizontal angle between the first and second courses.

The distance from the first to the second station is measured by chaining along the slope, the allignment being made by means of lamps, and the points corresponding to the ends of chains marked, by chalk-lines on the rock, or in some other convenient manner. The theodolite is then transferred to the third tripod, its place being taken by a station lamp, and the first tripod and lamp are carried along the gallery to mark the place of the fourth station; the same observations and measurements are made as before, and so on to the end of the traverse. The observations are recorded as shown in the following

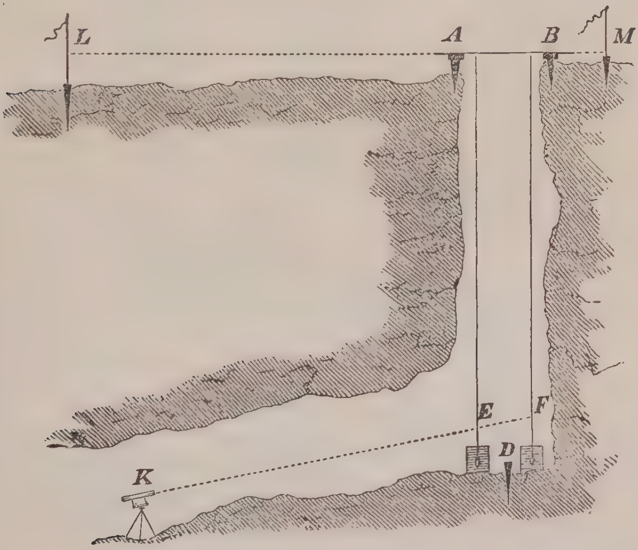
FIELD BOOK.

Station.	SLOPE.		Reading on hor. limb.		Horizontal Angle.	Dist. in feet.	REMARKS.
	Elevation.	Depression.	Back.	Fore.			
1	—	2° 30′					Station 1, at iron peg, centre of shaft.
2	—	3° 15′	107° 20′	283° 35′	176° 15′	307	
3	—	3° 30′	271° 15′	143° 30′	232° 15′	402	
4	—	4° 15′	109° 8′	337° 38′	228° 30′	240	
5	1° 30′	—	225° 15′	14° 30′	149° 15′	367	
6	2° 00′	—	15° 20′	198° 50′	183° 30′	409	
7						200	At iron peg.

When the bearing of the first course is known, the azimuth of that, and of the following courses, may be found, and the field-book, thus reduced to the form given in Art. 72. Sometimes, the first course is assumed as a line of departure, and the azimuths of the following courses are calculated with reference to it.

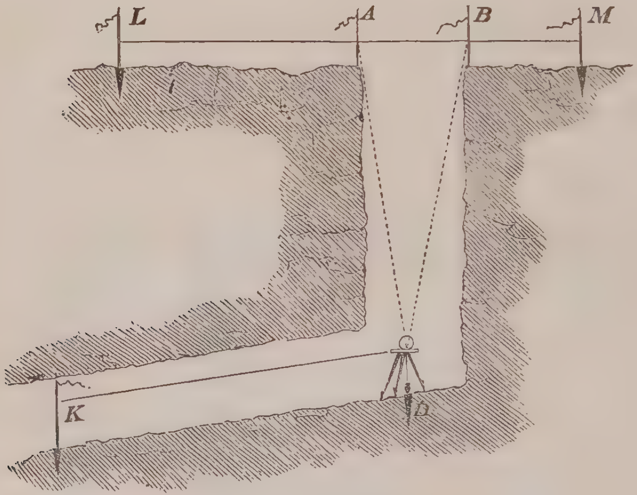
Modes of connecting with Surface Survey.

77. In order to determine the bearing of the first course, and also to be able to trace out the plan of the mine on the ground, it is often desirable to connect the underground traverse with the surface survey. There are two principal methods of making the connection.



FIRST METHOD.

A straight-edge, *AB*, is mounted on two trestles, and from it are suspended two plumb lines, *E* and *F*, as far apart as the breadth of the shaft will permit. To prevent agitation from currents of air, the bobs are permitted to dip into buckets of water, at the bottom of the shaft; the theodolite being at the *second* station, *K*, and the telescope turned in the direction of the first station, *D*, the straight-edge is moved by an assistant until both are seen in line from *K*; their plane then passes through the first course; and if the line *AB* be prolonged to *M* and *L*, the line *ML* will be directly over the first course, and consequently its bearing will be that of the first course. By measuring the line *E*, the depth of the shaft may be found.



SECOND METHOD.

Let the theodolite, provided with a diagonal eye-piece, be planted over the station *D*, at the foot of the shaft, and after being levelled, let it be directed on the station *K*. Then, without changing the plane of vision, let the theodolite be directed to the top of the shaft, and let an assistant plant two flag rods, one at *A* and the other at *B*, both in the plane of vision, and let the line *AB* be prolonged to *L* and *M*, as before. The line *LM* will be in the same vertical plane with the first course, *DK*. Hence, as before, we may determine the bearing of the first course of the traverse.

Reducing the Traverse.

78. We may now find the azimuths of the various courses. Suppose the bearing of the first course to be S. 23° W.; then will its azimuth be equal to 180° + 23°, or, 203°; the azimuths of each of the following courses, in order, may be found by the following

RULE.—*Subtract* 180° *from the horizontal angle, observing that the remainder may be either* + *or* — *; add the result to the preceding azimuth; if the sum is negative, add* 360° *to it; if positive and greater than* 360°, *subtract* 360° *from it; the result thus found is the azimuth required.*

Thus, in the given example, the horizontal angle between the first and second courses is 176° 15′; this diminished by 180°, gives — 3° 45′, which added to the preceding azimuth, 203°, gives 199° 15′ for the azimuth of the *second* course. In like manner, we find the azimuth of the *third* course, 251° 30′, of the *fourth*, 300°, of the *fifth*, 269° 15′, and of the *sixth*, 272° 45′. These are the same as are given in the example, in Article **72**.

Having found the data, as given in Article **72**, we proceed to reduce the traverse as shown in the following

OFFICE FORM.

Course.	Slope in ft.		Bearing.	Reduced length of course.	Latitude.		Departure.	
	Elevation.	Depression.			N.	S.	E.	W.
1	....	13.4	S. 23° W.	306.7	....	282.3	....	119.8
2	....	22.8	S. 19¼° W.	401.4	....	379.0	....	132.0
3	....	14.7	S. 71½° W.	239.6	....	76.0	....	227.2
4	....	27.2	N. 60° W.	366.	183.0	....	....	317.0
5	10.7	....	S. 89¼° W.	408.9	....	5.3	....	408.8
6	7.	....	N. 87¼° W.	199.9	9.6	....	....	199.7
	17.7	78.1			192.6	742.6	....	1404.5
		17.7				192.6	....	0.0
Resultant.	....	60.4	S. 68½° W.	1508.3	....	550.0	....	1404.5

The form requires but little explanation. From the azimuth, that is, the angle of the course from the north point around by the east, the bearing is easily deduced. The length of the course on the slope, multiplied by the sine of the slope, gives the distance the course rises or falls, in feet, and the length multiplied by the cosine of the slope, gives the reduced length of the course, that is, the length that would have been found had the course been measured on a horizontal line. The bearing and reduced course being found, the *latitudes* and *departures* of the courses are found in the usual manner. In the example given, the resultant course descends 60.4 feet, its southing is 550 feet, and its westing 1404.5; hence, its bearing and length on the horizontal, may easily be found by known methods.

If the depth of the shaft is known, this, added to the depression of the resultant, in feet, gives the distance of the last station below the horizontal plane through the mouth of the shaft.

Method of Plotting the Traverse on the Surface.

79. To plot the traverse on the surface of the earth, we lay down the direction of the first course, as already shown: on this, measure off, in the usual manner, the reduced length of the first course, and mark the end of this distance, by a peg; plant the compass over the peg, set it so that the reading of the needle is equal to the bearing of the second course, and in this direction measure off the reduced value of the second course, and so on to the end. Then will the several pegs be exactly over the corresponding stations in the mine.

80. Suppose it were required to sink a shaft, so as to strike the gallery at station 6, in the example given in Article **76**. It has been shown how to locate the point exactly over the station, (Art. **75**). Let a line of levels be run from the mouth of the first shaft, to this point, and find the difference of level corresponding to the two points. This with the depth of the station, in the mine, below the mouth of the shaft, will make known the depth of the shaft. This is a problem that frequently occurs in mining.

A similar problem often arises in railroad tunnelling. For example, if a tunnel is to be driven through a hill, it is often desirable to sink shafts, intermediate to the end headings, so as to strike the tunnel. Oftentimes, these shafts are used as starting-points for portions of the tunnel which are intended to meet the parts that are being opened from the headings.

Method of Plotting the Traverse on Paper.

81. To plot the traverse, on paper, we first plot the plan by the usual method of plotting compass-work, using the bearings and the reduced lengths of the courses. This gives the general direction of the horizontal projection of the traverse run; and from the measurements for cross section, the breadths of the gallery, on each side, may be plotted, and thence a complete *plan* of the mine may be constructed. We next plot the profile of the traverse, using, as in railroad plotting, two scales, one for horizontal distances, and the other and larger one, for vertical distances. The relation between the two scales will depend upon the circumstances of the case. Sometimes, both may be equal. The profile represents the undulation of the traverse, without reference to its horizontal deviations. Let us conceive vertical planes to be passed through all the courses. These will intersect each other in vertical lines. Take the one, through the first course, as the one on which the profile is to be delineated. Then, beginning with the plane through the last course, conceive the other planes to be revolved, in order, each about its intersection with the preceding one, to coincide

with it, and so on till all are brought into coincidence with the fixed one. The lines of the traverse will then be situated in one plane, and a plot of them, in this position, will be the profile required. The distances from the traverse to the floor and roof of the gallery, at different points, enable us to complete the profile.

A TABLE

OF

LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0·000000	26	1·414973	51	1·707570	76	1·880814
2	0·301030	27	1·431364	52	1·716003	77	1·886491
3	0·477121	28	1·447158	53	1·724276	78	1·892095
4	0·602060	29	1·462398	54	1·732394	79	1·897627
5	0·698970	30	1·477121	55	1·740363	80	1·903090
6	0·778151	31	1·491362	56	1·748188	81	1·908485
7	0·845098	32	1·505150	57	1·755875	82	1·913814
8	0·903090	33	1·518514	58	1·763428	83	1·919078
9	0·954243	34	1·531479	59	1·770852	84	1·924279
10	1·000000	35	1·544068	60	1·778151	85	1·929419
11	1·041393	36	1·556303	61	1·785330	86	1·934498
12	1·079181	37	1·568202	62	1·792392	87	1·939519
13	1·113943	38	1·579784	63	1·799341	88	1·944483
14	1·146128	39	1·591065	64	1·806181	89	1·949390
15	1·176091	40	1·602060	65	1·812913	90	1·954243
16	1·204120	41	1·612784	66	1·819544	91	1·959041
17	1·230449	42	1·623249	67	1·826075	92	1·963788
18	1·255273	43	1·633468	68	1·832509	93	1·968483
19	1·278754	44	1·643453	69	1·838849	94	1·973128
20	1·301030	45	1·653213	70	1·845098	95	1·977724
21	1·322219	46	1·662758	71	1·851258	96	1·982271
22	1·342423	47	1·672098	72	1·857333	97	1·986772
23	1·361728	48	1·681241	73	1·863323	98	1·991226
24	1·380211	49	1·690196	74	1·869232	99	1·995635
25	1·397940	50	1·698970	75	1·875061	100	2·000000

REMARK. In the following table, in the nine right hand columns of each page, where the first or leading figures change from 9's to 0's, points or dots are introduced in stead of the 0's, to catch the eye, and to indicate that from thence the two figures of the Logarithm to be taken from the second column, stand in the next line below

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112	9218	9606	9993	•380	•766	1153	1538	1924	2309	2694	386
113	053078	3463	3846	4230	4613	4996	5378	5760	6142	6524	382
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117	8186	8557	8928	9298	9668	••38	•407	•776	1145	1514	369
118	071882	2250	2617	2985	3352	3718	4085	4451	4816	5182	366
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123	9905	•258	•611	•963	1315	1667	2018	2370	2721	3071	351
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165	7484	7747	8010	8273	8536	8798	9060	9323	9585	9846	262
166	220108	0370	0631	0892	1153	1414	1675	1936	2196	2456	261
167	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
168	5309	5568	5826	6084	6342	6600	6858	7115	7372	7630	258
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176	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	246
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182	260071	0310	0548	0787	1025	1263	1501	1739	1976	2214	238
183	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
184	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
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186	9513	9746	9980	•213	•446	•679	•912	1144	1377	1609	233
187	271842	2074	2306	2538	2770	3001	3233	3464	3696	3927	232
188	4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	230
189	6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	229
190	278754	8982	9211	9439	9667	9895	•123	•351	•578	•806	228
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193	5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	225
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209	320146	0354	0562	0769	0977	1184	1391	1598	1805	2012	207
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222	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
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226	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	192
227	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
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232	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	187
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234	9216	9401	9587	9772	9958	•143	•328	•513	•698	•883	185
235	371068	1253	1437	1622	1806	1991	2175	2360	2544	2728	184
236	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
237	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
238	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
239	8398	8580	8761	8943	9124	9306	9487	9668	9849	••30	181
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242	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
243	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
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247	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	175
248	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
249	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
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254	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
255	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
256	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
257	9933	•102	•271	•440	•609	•777	•946	1114	1283	1451	169
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259	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	5140	5307	5474	5641	5808	5974	6141	6308	6474	167
261	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
262	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
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266	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
267	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
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269	9752	9914	••75	•236	•398	•559	•720	•881	1042	1203	161
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272	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
273	6163	6322	6481	6640	6798	6957	7116	7275	7433	7592	159
274	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
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278	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
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285	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	152
286	6366	6518	6670	6821	6973	7125	7276	7428	7579	7731	152
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292	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	149
293	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	148
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295	9822	9969	•116	•263	•410	•557	•704	•851	•998	1145	147
296	471292	1438	1585	1732	1878	2025	2171	2318	2464	2610	146
297	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
298	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	146
299	5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	145
300	477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	145
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302	480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
303	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
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307	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
308	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
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334	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
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771	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
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817	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
818	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
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843	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	51
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886	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
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894	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
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947	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
948	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
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954	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
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956	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
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981	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
982	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
983	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
984	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
985	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
986	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
987	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
988	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
989	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	5679	5723	5767	5811	5854	5898	5942	5986	6030	44
991	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
992	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
993	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
994	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
995	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
996	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
997	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
998	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
999	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
N.	0	1	2	3	4	5	6	7	8	9	D.

A TABLE

OF

LOGARITHMIC

SINES AND TANGENTS

FOR EVERY

DEGREE AND MINUTE

OF THE QUADRANT.

Remark. The minutes in the left-hand column of each page, increasing downwards, belong to the degrees at the top; and those increasing upwards, in the right-hand column, belong to the degrees below.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0			10·000000		0·000000		Infinite.	60
1	6·463726	5017·17	000000	·00	6·463726	5017·17	13·536274	59
2	764756	2934·85	000000	·00	764756	2934·83	235244	58
3	940847	2082·31	000000	·00	940847	2082·31	059153	57
4	7·065786	1615·17	000000	·00	7·065786	1615·17	12·934214	56
5	162696	1319·68	000000	·00	162696	1319·69	837304	55
6	241877	1115·75	9·999999	·01	241878	1115·78	758122	54
7	308824	966·53	999999	·01	308825	996·53	691175	53
8	366816	852·54	999999	·01	366817	852·54	633183	52
9	417968	762·63	999999	·01	417970	762·63	582030	51
10	463725	689·88	999998	·01	463727	689·88	536273	50
11	7·505118	629·81	9·999998	·01	7·505120	629·81	12·494880	49
12	542906	579·36	999997	·01	542909	579·33	457091	48
13	577668	536·41	999997	·01	577672	536·42	422328	47
14	609853	499·38	999996	·01	609857	499·39	390143	46
15	639816	467·14	999996	·01	639820	467·15	360180	45
16	667845	438·81	999995	·01	667849	438·82	332151	44
17	694173	413·72	999995	·01	694179	413·73	305821	43
18	718997	391·35	999994	·01	719004	391·36	280997	42
19	742477	371·27	999993	·01	742484	371·28	257516	41
20	764754	353·15	999993	·01	764761	351·25	235239	40
21	7·785943	336·72	9·999992	·01	7·785951	336·73	12·214049	39
22	806146	321·75	999991	·01	806155	321·76	193845	38
23	825451	308·05	999990	·01	825460	308·06	174540	37
24	843934	295·47	999989	·02	843944	295·49	156056	36
25	861662	283·88	999988	·02	861674	283·90	138326	35
26	878695	273·17	999988	·02	878708	273·18	121292	34
27	895085	263·23	999987	·02	895099	263·25	104901	33
28	910879	253·99	999986	·02	910894	254·01	089106	32
29	926119	245·38	999985	·02	926134	245·40	073866	31
30	940842	237·33	999983	·02	940858	237·35	059142	30
31	7·955082	229·80	9·999982	·02	7·955100	229·81	12·044900	29
32	968870	222·73	999981	·02	968889	222·75	031111	28
33	982233	216·08	999980	·02	982253	216·10	017747	27
34	995198	209·81	999979	·02	995219	209·83	004781	26
35	8·007787	203·90	999977	·02	8·007809	203·92	11·992191	25
36	020021	198·31	999976	·02	020045	198·33	979955	24
37	031919	193·02	999975	·02	031945	193·05	968055	23
38	043501	188·01	999973	·02	043527	188·03	956473	22
39	054781	183·25	999972	·02	054809	183·27	945191	21
40	065776	178·72	999971	·02	065806	178·74	934194	20
41	8·076500	174·41	9·999969	·02	8·076531	174·44	11·923469	19
42	086965	170·31	999968	·02	086997	170·34	913003	18
43	097183	166·39	999966	·02	097217	166·42	902783	17
44	107167	162·65	999964	·03	107202	162·68	892797	16
45	116926	159·08	999963	·03	116963	159·10	883037	15
46	126471	155·66	999961	·03	126510	155·68	873490	14
47	135810	152·38	999959	·03	135851	152·41	864149	13
48	144953	149·24	999958	·03	144996	149·27	855004	12
49	153907	146·22	999955	·03	153952	146·27	846048	11
50	162681	143·33	999954	·03	162727	143·36	837273	10
51	3·171280	140·54	9·999952	·03	8·171328	140·57	11·828672	9
52	179713	137·86	999950	·03	179763	137·00	820237	8
53	187985	135·29	999948	·03	188036	135·32	811964	7
54	196102	132·80	999946	·03	196156	132·84	803844	6
55	204070	130·41	999944	·03	204126	130·44	795874	5
56	211895	128·10	999942	·04	211953	128·14	788047	4
57	219581	125·87	999940	·04	219641	125·90	780359	3
58	227134	123·72	999938	·04	227195	123·76	772805	2
59	234557	121·64	999936	·04	234621	121·68	765379	1
60	241855	119·63	999934	·04	241921	119·67	758079	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(89 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·241855	119·63	9·999934	·04	8·241921	119·67	11·758079	60
1	249033	117·68	999932	·04	249102	117·72	750898	59
2	256094	115·80	999929	·04	256165	115·84	743835	58
3	263042	113·98	999927	·04	263115	114·02	736885	57
4	269881	112·21	999925	·04	269956	112·25	730044	56
5	276614	110·50	999922	·04	276691	110·54	723309	55
6	283243	108·83	999920	·04	283323	108·87	716677	54
7	289773	107·21	999918	·04	289856	107·26	710144	53
8	296207	105·65	999915	·04	296292	105·70	703708	52
9	302546	104·13	999913	·04	302634	104·18	697366	51
10	308794	102·66	999910	·04	308884	102·70	691116	50
11	8·314904	101·22	9·999907	·04	8·315046	101·26	11·684954	49
12	321027	99·82	999905	·04	321122	99·87	678878	48
13	327016	98·47	999902	·04	327114	98·51	672886	47
14	332924	97·14	999899	·05	333025	97·19	666975	46
15	338753	95·86	999897	·05	338856	95·90	661144	45
16	344504	94·60	999894	·05	344610	94·65	655390	44
17	350181	93·38	999891	·05	350289	93·43	649711	43
18	355783	92·19	999888	·05	355895	92·24	644105	42
19	361315	91·03	999885	·05	361430	91·08	638570	41
20	366777	89·90	999882	·05	366895	89·95	633105	40
21	8·372171	88·80	9·999879	·05	8·372292	88·85	11·627708	39
22	377499	87·72	999876	·05	377622	87·77	622378	38
23	382762	86·67	999873	·05	382889	86·72	617111	37
24	387962	85·64	999870	·05	388092	85·70	611908	36
25	393101	84·64	999867	·05	393234	84·70	606766	35
26	398179	83·66	999864	·05	398315	83·71	601685	34
27	403199	82·71	999861	·05	403338	82·76	596662	33
28	408161	81·77	999858	·05	408304	81·82	591696	32
29	413068	80·86	999854	·05	413213	80·91	586787	31
30	417919	79·96	999851	·06	418068	80·02	581932	30
31	8·422717	79·09	9·999848	·06	8·422869	79·14	11·577131	29
32	427462	78·23	999844	·06	427618	78·30	572382	28
33	432156	77·40	999841	·06	432315	77·45	567685	27
34	436800	76·57	999838	·06	436962	76·63	563038	26
35	441394	75·77	999834	·06	441560	75·83	558440	25
36	445941	74·99	999831	·06	446110	75·05	553890	24
37	450440	74·22	999827	·06	450613	74·28	549387	23
38	454893	73·46	999823	·06	455070	73·52	544930	22
39	459301	72·73	999820	·06	459481	72·79	540519	21
40	463665	72·00	999816	·06	463849	72·06	536151	20
41	8·467985	71·29	9·999812	·06	8·468172	71·35	11·531828	19
42	472263	70·60	999809	·06	472454	70·66	527546	18
43	476498	69·91	999805	·06	476693	69·98	523307	17
44	480603	69·24	999801	·06	480892	69·31	519108	16
45	484848	68·59	999797	·07	485050	68·65	514950	15
46	488963	67·94	999793	·07	489170	68·01	510830	14
47	493040	67·31	999790	·07	493250	67·38	506750	13
48	497078	66·69	999786	·07	497293	66·76	502707	12
49	501080	66·08	999782	·07	501298	66·15	498702	11
50	505045	65·48	999778	·07	505267	65·55	494733	10
51	8·508974	64·89	9·999774	·07	8·509200	64·96	11·490800	9
52	512867	64·31	999769	·07	513098	64·39	486902	8
53	516726	63·75	999765	·07	516961	63·82	483039	7
54	520551	63·19	999761	·07	520790	63·26	479210	6
55	524343	62·64	999757	·07	524586	62·72	475414	5
56	528102	62·11	999753	·07	528349	62·18	471651	4
57	531828	61·58	999748	·07	532080	61·65	467920	3
58	535523	61·06	999744	·07	535779	61·13	464221	2
59	539186	60·55	999740	·07	539447	60·62	460553	1
60	542819	60·04	999735	·07	543084	60·12	456916	0
	Cosine	D.	Sine		Cotang.	D.	Tang	

(88 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·542819	60·04	9·999735	·07	8·543084	60·12	11·456916	60
1	546422	59·55	999731	·07	546691	59·62	453309	59
2	549995	59·06	999726	·07	550268	59·14	449732	58
3	553539	58·58	999722	·08	553817	58·66	446183	57
4	557054	58·11	999717	·08	557336	58·19	442664	56
5	560540	57·65	999713	·08	560828	57·73	439172	55
6	563999	57·19	999708	·08	564291	57·27	435709	54
7	567431	56·74	999704	·08	567727	56·82	432273	53
8	570836	56·30	999699	·08	571137	56·38	428863	52
9	574214	55·87	999694	·08	574520	55·95	425480	51
10	577566	55·44	999689	·08	577877	55·52	422123	50
11	8·580892	55·02	9·999685	·08	8·581208	55·10	11·418792	49
12	584193	54·60	999680	·08	584514	54·68	415486	48
13	587469	54·19	999675	·08	587795	54·27	412205	47
14	590721	53·79	999670	·08	591051	53·87	408949	46
15	593948	53·39	999665	·08	594283	53·47	405717	45
16	597152	53·00	999660	·08	597492	53·08	402508	44
17	600332	52·61	999655	·08	600677	52·70	399323	43
18	603489	52·23	999650	·08	603839	52·32	396161	42
19	606623	51·86	999645	·09	606978	51·94	393022	41
20	609734	51 49	999640	·09	610094	51·58	389906	40
21	8·612823	51·12	9·999635	·09	8·613189	51·21	11·386811	39
22	615891	50·76	999629	·09	616262	50·85	383738	38
23	618937	50·41	999624	·09	619313	50·50	380687	37
24	621962	50·06	999619	·09	622343	50·15	377657	36
25	624965	49·72	999614	·09	625352	49·81	374648	35
26	627948	49·38	999608	·09	628340	49·47	371660	34
27	630911	49·04	999603	·09	631308	49·13	368692	33
28	633854	48·71	999597	·09	634256	48·80	365744	32
29	636776	48·39	999592	·09	637184	48·48	362816	31
30	639680	48·06	999586	·09	640093	48·16	359907	30
31	8·642563	47·75	9·999581	·09	8·642982	47·84	11·357018	29
32	645428	47·43	999575	·09	645853	47·53	354147	28
33	648274	47·12	999570	·09	648704	47·22	351296	27
34	651102	46·82	999564	·09	651537	46·91	348463	26
35	653911	46·52	999558	·10	654352	46·61	345648	25
36	656702	46·22	999553	·10	657149	46·31	342851	24
37	659475	45·92	999547	·10	659928	46·02	340072	23
38	662230	45·63	999541	·10	662689	45·73	337311	22
39	664968	45·35	999535	·10	665433	45·44	334567	21
40	667689	45·06	999529	·10	668160	45·26	331840	20
41	8·670393	44·79	9·999524	·10	8·670870	44·88	11·329130	19
42	673080	44·51	999518	·10	673563	44·61	326437	18
43	675751	44·24	999512	·10	676239	44·34	323761	17
44	678405	43·97	999506	·10	678900	44·17	321100	16
45	681043	43·70	999500	·10	681544	43·80	318456	15
46	683665	43·44	999493	·10	684172	43·54	315828	14
47	686272	43·18	999487	·10	686784	43·28	313216	13
48	688863	42·92	999481	·10	689381	43·03	310619	12
49	691438	42·67	999475	·10	691963	42·77	308037	11
50	693998	42·42	999469	·10	694529	42·52	305471	10
51	8·696543	42·17	9·999463	·11	8·697081	42·28	11·302919	9
52	699073	41·92	999456	·11	699617	42·03	300383	8
53	701589	41·68	999450	·11	702139	41·79	297861	7
54	704090	41·44	999443	·11	704646	41·55	295354	6
55	706577	41·21	999437	·11	707140	41·32	292860	5
56	709049	40·97	999431	·11	709618	41·08	290382	4
57	711507	40·74	999424	·11	712083	40·85	287917	3
58	713952	40·51	999418	·11	714534	40·62	285465	2
59	716383	40·29	999411	·11	716972	40·40	283028	1
60	718800	40·06	999404	·11	719396	40·17	280604	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·718800	40·06	9·999404	·11	8·719396	40·17	11·280604	60
1	721204	39·84	999398	·11	721806	39·95	278194	59
2	723595	39·62	999391	·11	724204	39·74	275796	58
3	725972	39·41	999384	·11	726588	39·52	273412	57
4	728337	39·19	999378	·11	728959	39·30	271041	56
5	730688	38·98	999371	·11	731317	39·09	268683	55
6	733027	38·77	999364	·12	733663	38·89	266337	54
7	735354	38·57	999357	·12	735996	38·68	264004	53
8	737667	38·36	999350	·12	738317	38·48	261683	52
9	739969	38·16	999343	·12	740626	38·27	259374	51
10	742259	37·96	999336	·12	742922	38·07	257078	50
11	8·744536	37·76	9·999329	·12	8·745207	37·87	11·254793	49
12	746802	37·56	999322	·12	747479	37·68	252521	48
13	749055	37·37	999315	·12	749740	37·49	250260	47
14	751297	37·17	999308	·12	751989	37·29	248011	46
15	753528	36·98	999301	·12	754227	37·10	245773	45
16	755747	36·79	999294	·12	756453	36·92	243547	44
17	757955	36·61	999286	·12	758668	36·73	241332	43
18	760151	36·42	999279	·12	760872	36·55	239128	42
19	762337	36·24	999272	·12	763065	36·36	236935	41
20	764511	36·06	999265	·12	765246	36·18	234754	40
21	8·766675	35·88	9·999257	·12	8·767417	36·00	11·232583	39
22	768828	35·70	999250	·13	769578	35·83	230422	38
23	770970	35·53	999242	·13	771727	35·65	228273	37
24	773101	35·35	999235	·13	773866	35·48	226134	36
25	775223	35·18	999227	·13	775995	35·31	224005	35
26	777333	35·01	999220	·13	778114	35·14	221886	34
27	779434	34·84	999212	·13	780222	34·97	219778	33
28	781524	34·67	999205	·13	782320	34·80	217680	32
29	783605	34·51	999197	·13	784408	34·64	215592	31
30	785675	34·31	999189	·13	786486	34·47	213514	30
31	8·787736	34·18	9·999181	·13	8·788554	34·31	11·211446	29
32	789787	34·02	999174	·13	790613	34·15	209387	28
33	791828	33·86	999166	·13	792662	33·99	207338	27
34	793859	33·70	999158	·13	794701	33·83	205299	26
35	795881	33·54	999150	·13	796731	33·68	203269	25
36	797894	33·39	999142	·13	798752	33·52	201248	24
37	799897	33·23	999134	·13	800763	33·37	199237	23
38	801892	33·08	999126	·13	802765	33·22	197235	22
39	803876	32·93	999118	·13	804758	33·07	195242	21
40	805852	32·78	999110	·13	806742	32·92	193258	20
41	8·807819	32·63	9·999102	·13	8·808717	32·78	11·191283	19
42	809777	32·49	999094	·14	810683	32·62	189317	18
43	811726	32·34	999086	·14	812641	32·48	187359	17
44	813667	32·19	999077	·14	814589	32·33	185411	16
45	815599	32·05	999069	·14	816529	32·19	183471	15
46	817522	31·91	999061	·14	818461	32·05	181539	14
47	819436	31·77	999053	·14	820384	31·91	179616	13
48	821343	31·63	999044	·14	822298	31·77	177702	12
49	823240	31·49	999036	·14	824205	31·63	175795	11
50	825130	31·35	999027	·14	826103	31·50	173897	10
51	8·827011	31·22	9·999019	·14	8·827992	31·36	11·172008	9
52	828884	31·08	999010	·14	829874	31·23	170126	8
53	830749	30·95	999002	·14	831748	31·10	168252	7
54	832607	30·82	998993	·14	833613	30·96	166387	6
55	834456	30·69	998984	·14	835471	30·83	164529	5
56	836297	30·56	998976	·14	837321	30·70	162679	4
57	838130	30·43	998967	·15	839163	30·57	160837	3
58	839956	30·30	998958	·15	840998	30·45	159002	2
59	841774	30·17	998950	·15	842825	30·32	157175	1
60	843585	30·00	998941	·15	844644	30·19	155356	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(86 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·843585	30·05	9·998941	·15	8·844644	30·19	11·155356	60
1	845387	29·92	998932	·15	846455	30·07	153545	59
2	847183	29·80	998923	·15	848260	29·95	151740	58
3	848971	29·67	998914	·15	850057	29·82	149943	57
4	850751	29·55	998905	·15	851846	29·70	148154	56
5	852525	29·43	998896	·15	853628	29·58	146372	55
6	854291	29·31	998887	·15	855403	29·46	144597	54
7	856049	29·19	998878	·15	857171	29·35	142829	53
8	857801	29·07	998869	·15	858932	29·23	141068	52
9	859546	28·96	998860	·15	860686	29·11	139314	51
10	861283	28·84	998851	·15	862433	29·00	137567	50
11	8·863014	28·73	9·998841	·15	8·864173	28·88	11·135827	49
12	864738	28·61	998832	·15	865906	28·77	134094	48
13	866455	28·50	998823	·16	867632	28·66	132368	47
14	868165	28·39	998813	·16	869351	28·54	130649	46
15	869868	28·28	998804	·16	871064	28·43	128936	45
16	871565	28·17	998795	·16	872770	28·32	127230	44
17	873255	28·06	998785	·16	874469	28·21	125531	43
18	874938	27·95	998776	·16	876162	28·11	123838	42
19	876615	27·86	998766	·16	877849	28·00	122151	41
20	878285	27·73	998757	·16	879529	27·89	120471	40
21	8·879949	27·63	9·998747	·16	8·881202	27·79	11·118798	39
22	881607	27·52	998738	·16	882869	27·68	117131	38
23	883258	27·42	998728	·16	884530	27·58	115470	37
24	884903	27·31	998718	·16	886185	27·47	113815	36
25	886542	27·21	998708	·16	887833	27·37	112167	35
26	888174	27·11	998699	·16	889476	27·27	110524	34
27	889801	27·00	998689	·16	891112	27·17	108888	33
28	891421	26·90	998679	·16	892742	27·07	107258	32
29	893035	26·80	998669	·17	894366	26·97	105634	31
30	894643	26·70	998659	·17	895984	26·87	104016	30
31	8·896246	26·60	9·998649	·17	8·897596	26·77	11·102404	29
32	897842	26·51	998639	·17	899203	26·67	100797	28
33	899432	26·41	998629	·17	900803	26·58	099197	27
34	901017	26·31	998619	·17	902398	26·48	097602	26
35	902596	26·22	998609	·17	903987	26·38	096013	25
36	904169	26·12	998599	·17	905570	26·29	094430	24
37	905736	26·03	998589	·17	907147	26·20	092853	23
38	907297	25·93	998578	·17	908719	26·10	091281	22
39	908853	25·84	998568	·17	910285	26·01	089715	21
40	910404	25·75	998558	·17	911846	25·92	088154	20
41	8·911949	25·66	9·998548	·17	8·913401	25·83	11·086599	19
42	913488	25·56	998537	·17	914951	25·74	085049	18
43	915022	25·47	998527	·17	916495	25·65	083505	17
44	916550	25·38	998516	·18	918034	25·56	081966	16
45	918073	25·29	998506	·18	919568	25·47	080432	15
46	919591	25·20	998495	·18	921096	25·38	078904	14
47	921103	25·12	998485	·18	922619	25·30	077381	13
48	922610	25·03	998474	·18	924136	25·21	075864	12
49	924112	24·94	998464	·18	925649	25·12	074351	11
50	925609	24·86	998453	·18	927156	25·03	072844	10
51	8·927100	24·77	9·998442	·18	8·928658	24·95	11 071342	9
52	928587	24·69	998431	·18	930155	24·86	069845	8
53	930068	24·60	998421	·18	931647	24·78	068353	7
54	931544	24·52	998410	·18	933134	24·70	066866	6
55	933015	24·43	998399	·18	934616	24·61	065384	5
56	934481	24·35	998388	·18	936093	24·53	063907	4
57	935942	24·27	998377	·18	937565	24·45	062435	3
58	937398	24·19	998366	·18	939032	24·37	060968	2
59	938850	24·11	998355	·18	940494	24·30	059506	1
60	940296	24·03	998344	·18	941952	24·21	058048	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(85 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8·940296	24·03	9·998344	·19	8·941952	24·21	11·058048	60
1	941738	23·94	998333	·19	943404	24·13	056596	59
2	943174	23·87	998322	·19	944852	24·05	055148	58
3	944606	23·79	998311	·19	946295	23·97	053705	57
4	946034	23·71	998300	·19	947734	23·90	052266	56
5	947456	23·63	998289	·19	949168	23·82	050832	55
6	948874	23·55	998277	·19	950597	23·74	049403	54
7	950287	23·48	998266	·19	952021	23·66	047979	53
8	951696	23·40	998255	·19	953441	23·60	046559	52
9	953100	23·32	998243	·19	954856	23·51	045144	51
10	954499	23·25	998232	·19	956267	23·44	043733	50
11	8·955894	23·17	9·998220	·19	8·957674	23·37	11·042326	49
12	957284	23·10	998209	·19	959075	23·29	040925	48
13	958670	23·02	998197	·19	960473	23·23	039527	47
14	960052	22·95	998186	·19	961866	23·14	038134	46
15	961429	22·88	998174	·19	963255	23·07	036745	45
16	962801	22·80	998163	·19	964639	23·00	035361	44
17	964170	22·73	998151	·19	966019	22·93	033981	43
18	965534	22·66	998139	·20	967394	22·86	032606	42
19	966893	22·59	998128	·20	968766	22·79	031234	41
20	968249	22·52	998116	·20	970133	22·71	029867	40
21	8·969600	22·44	9·998104	·20	8·971496	22·65	11·028504	39
22	970947	22·38	998092	·20	972855	22·57	027145	38
23	972289	22·31	998080	·20	974209	22·51	025791	37
24	973628	22·24	998068	·20	975560	22·44	024440	36
25	974962	22·17	998056	·20	976906	22·37	023094	35
26	976293	22·10	998044	·20	978248	22·30	021752	34
27	977619	22·03	998032	·20	979586	22·23	020414	33
28	978941	21·97	998020	·20	980921	22·17	019079	32
29	980259	21·90	998008	·20	982251	22·10	017749	31
30	981573	21·83	997996	·20	983577	22·04	016423	30
31	8·982883	21·77	9·997985	·20	8·984899	21·97	11·015101	29
32	984189	21·70	997972	·20	986217	21·91	013783	28
33	985491	21·63	997959	·20	987532	21·84	012468	27
34	986789	21·57	997947	·20	988842	21·78	011158	26
35	988083	21·50	997935	·21	990149	21·71	009851	25
36	989374	21·44	997922	·21	991451	21·65	008549	24
37	990660	21·38	997910	·21	992750	21·58	007250	23
38	991943	21·31	997897	·21	994045	21·52	005955	22
39	993222	21·25	997885	·21	995337	21·46	004663	21
40	994497	21·19	997872	·21	996624	21·40	003376	20
41	8·995768	21·12	9·997860	·21	8·997908	21·34	11·002092	19
42	997036	21·06	997847	·21	999188	21·27	000812	18
43	998299	21·00	997835	·21	9·000465	21·21	10·999535	17
44	999560	20·94	997822	·21	001738	21·15	998262	16
45	9·000816	20·87	997809	·21	003007	21·09	996993	15
46	002069	20·82	997797	·21	004272	21·03	995728	14
47	003318	20·76	997784	·21	005534	20·97	994466	13
48	004563	20·70	997771	·21	006792	20·91	993208	12
49	005805	20·64	997758	·21	008047	20·85	991953	11
50	007044	20·58	997745	·21	009298	20·80	990702	10
51	9·008278	20·52	9·997732	·21	9·010546	20·74	10·989454	9
52	009510	20·46	997719	·21	011790	20·68	988210	8
53	010737	20·40	997706	·21	013031	20·62	986969	7
54	011962	20·34	997693	·22	014268	20·56	985732	5
55	013182	20·29	997680	·22	015502	20·51	984498	5
56	014400	20·23	997667	·22	016732	20·45	983268	4
57	015613	20·17	997654	·22	017959	20·40	982041	3
58	016824	20·12	997641	·22	019183	20·33	980817	2
59	018031	20·06	997628	·22	020403	20·28	979597	1
60	019235	20·00	997614	·22	021620	20·23	978380	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(84 DEGREES.)

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·019235	20·00	9·997614	·22	9·021620	20·23	10·978380	60
1	020435	19·95	997601	·22	022834	20·17	977166	59
2	021632	19·89	997588	·22	024044	20·11	975956	58
3	022825	19·84	997574	·22	025251	20·06	974749	57
4	024016	19·78	997561	·22	026455	20·00	973545	56
5	025203	19·73	997547	·22	027655	19·95	972345	55
6	026386	19·67	997534	·23	028852	19·90	971148	54
7	027567	19·62	997520	·23	030046	19·85	969954	53
8	028744	19·57	997507	·23	031237	19·79	968763	52
9	029918	19·51	997493	·23	032425	19·74	967575	51
10	031089	19·47	997480	·23	033609	19·69	966391	50
11	9·032257	19·41	9·997466	·23	9·034791	19·64	10·965209	49
12	033421	19·36	997452	·23	035969	19·58	964031	48
13	034582	19·30	997439	·23	037144	19·53	962856	47
14	035741	19·25	997425	·23	038316	19·48	961684	46
15	036896	19·20	997411	·23	039485	19·43	960515	45
16	038048	19·15	997397	·23	040651	19·38	959349	44
17	039197	19·10	997383	·23	041813	19·33	958187	43
18	040342	19·05	997369	·23	042973	19·28	957027	42
19	041485	18·99	997355	·23	044130	19·23	955870	41
20	042625	18·94	997341	·23	045284	19·18	954716	40
21	9·043762	18·89	9·997327	·24	9·046434	19·13	10·953566	39
22	044895	18·84	997313	·24	047582	19·08	952418	38
23	046026	18·79	697299	·24	048727	19·03	951273	37
24	047154	18·75	997285	·24	049869	18·98	950131	36
25	048279	18·70	997271	·24	051008	18·93	948992	35
26	049400	18·65	997257	·24	052144	18·89	947856	34
27	050519	18·60	997242	·24	053277	18·84	946723	33
28	051635	18·55	997228	·24	054407	18·79	945593	32
29	052749	18·50	997214	·24	055535	18·74	944465	31
30	053859	18·45	997199	·24	056659	18·70	943341	30
31	9·054966	18·41	9·997185	·24	9·057781	18·65	10·942219	29
32	056071	18·36	997170	·24	058900	18·60	941100	28
33	057172	18·31	997156	·24	060016	18·55	939984	27
34	058271	18·27	997141	·24	061130	18·51	938870	26
35	059367	18·22	997127	·24	062240	18·46	937760	25
36	060460	18·17	997112	·24	063348	18·42	936652	24
37	061551	18·13	997098	·24	064453	18·37	935547	23
38	062639	18·08	997083	·25	065556	18·33	934444	22
39	063724	18·04	997068	·25	066655	18·28	933345	21
40	064806	17·99	997053	·25	067752	18·24	932248	20
41	9·065885	17·94	9·997039	·25	9·068846	18·19	10·931154	19
42	066962	17·90	997024	·25	069938	18·15	930062	18
43	068036	17·86	997009	·25	071027	18·10	928973	17
44	069107	17·81	996994	·25	072113	18·06	927887	16
45	070176	17·77	996979	·25	073197	18·02	926803	15
46	071242	17·72	996964	·25	074278	17·97	925722	14
47	072306	17·68	996949	·25	075356	17·93	924644	13
48	073366	17·63	996934	·25	076432	17·89	923568	12
49	074424	17·59	996919	·25	077505	17·84	922495	11
50	075480	17·55	996904	·25	078576	17·80	921424	10
51	9·076533	17·50	9·996889	·25	9·079644	17·76	10·920356	9
52	077583	17·46	996874	·25	080710	17·72	919290	8
53	078631	17·42	996858	·25	081773	17·67	918227	7
54	079676	17·38	996843	·25	082833	17·63	917167	6
55	080719	17·33	996828	·25	083891	17·59	916109	5
56	081759	17·29	996812	·26	084947	17·55	915053	4
57	082797	17·25	996797	·26	086000	17·51	914000	3
58	083832	17·21	996782	·26	087050	17·47	912950	2
59	084864	17·17	996766	·26	088098	17·43	911902	1
60	085894	17·13	996751	·26	089144	17·38	910856	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·085894	17·13	9·996751	·26	9·089144	17·38	10·910856	60
1	086922	17·09	996735	·26	090187	17·34	909813	59
2	087947	17·04	996720	·26	091228	17·30	908772	58
3	088970	17·00	996704	·26	092266	17·27	907734	57
4	089990	16·96	996688	·26	093302	17·22	906698	56
5	091008	16·92	996673	·26	094336	17·19	905664	55
6	092024	16·88	996657	·26	095367	17·15	904633	54
7	093037	16·84	996641	·26	096395	17·11	903605	53
8	094047	16·80	996625	·26	097422	17·07	902578	52
9	095056	16·76	996610	·26	098446	17·03	901554	51
10	096062	16·73	996594	·26	099468	16·99	900532	50
11	9·097065	16·68	9·996578	·27	9·100487	16·95	10·899513	49
12	098066	16·65	996562	·27	101504	16·91	898496	48
13	099065	16·61	996546	·27	102519	16·87	897481	47
14	100062	16·57	996530	·27	103532	16·84	896468	46
15	101056	16·53	996514	·27	104542	16·80	895458	45
16	102048	16·49	996498	·27	105550	16·76	894450	44
17	103037	16·45	996482	·27	106556	16·72	893444	43
18	104025	16·41	996465	·27	107559	16·69	892441	42
19	105010	16·38	996449	·27	108560	16·65	891440	41
20	105992	16·34	996433	·27	109559	16·61	890441	40
21	9·106973	16·30	9·996417	·27	9·110556	16·58	10·889444	39
22	107951	16·27	996400	·27	111551	16·54	888449	38
23	108927	16·23	996384	·27	112543	16·50	887457	37
24	109901	16·19	996368	·27	113533	16·46	886467	36
25	110873	16·16	996351	·27	114521	16·43	885479	35
26	111842	16·12	996335	·27	115507	16·39	884493	34
27	112809	16·08	996318	·27	116491	16·36	883509	33
28	113774	16·05	996302	·28	117472	16·32	882528	32
29	114737	16·01	996285	·28	118452	16·29	881548	31
30	115698	15·97	996269	·28	119429	16·25	880571	30
31	9·116656	15·94	9·996252	·28	9·120404	16·22	10·879596	29
32	117613	15·90	996235	·28	121377	16·18	878623	28
33	118567	15·87	996219	·28	122348	16·15	877652	27
34	119519	15·83	996202	·28	123317	16·11	876683	26
35	120469	15·80	996185	·28	124284	16·07	875716	25
36	121417	15·76	996168	·28	125249	16·04	874751	24
37	122362	15·73	996151	·28	126211	16·01	873789	23
38	123306	15·69	996134	·28	127172	15·97	872828	22
39	124248	15·66	996117	·28	128130	15·94	871870	21
40	125187	15·62	996100	·28	129087	15·91	870913	20
41	9·126125	15·59	9·996083	·29	9·130041	15·87	10·869959	19
42	127060	15·56	996066	·29	130994	15·84	869006	18
43	127993	15·52	996049	·29	131944	15·81	868056	17
44	128925	15·49	996032	·29	132893	15·77	867107	16
45	129854	15·45	996015	·29	133839	15·74	866161	15
46	130781	15·42	995998	·29	134784	15·71	865216	14
47	131706	15·39	995980	·29	135726	15·67	864274	13
48	132630	15·35	995963	·29	136667	15·64	863333	12
49	133551	15·32	995946	·29	137605	15·61	862395	11
50	134470	15·29	995928	·29	138542	15·58	861458	10
51	9·135387	15·25	9·995911	·29	9·139476	15·55	10·860524	9
52	136303	15·22	995894	·29	140409	15·51	859591	8
53	137216	15·19	995876	·29	141340	15·48	858660	7
54	138128	15·16	995859	·29	142269	15·45	857731	6
55	139037	15·12	995841	·29	143196	15·42	856804	5
56	139944	15·09	995823	·29	144121	15·39	855879	4
57	140850	15·06	995806	·29	145044	15·35	854956	3
58	141754	15·03	995788	·29	145966	15·32	854034	2
59	142655	15·00	995771	·29	146885	15·29	853115	1
60	143555	14·96	995753	·29	147803	15·26	852197	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(82 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·143555	14·96	9·995753	·30	9·147803	15·26	10·852197	60
1	144453	14·93	995735	·30	148718	15·23	851282	59
2	145349	14·90	995717	·30	149632	15·20	850368	58
3	146243	14·87	995699	·30	150544	15·17	849456	57
4	147136	14·84	995681	·30	151454	15·14	848546	56
5	148026	14·81	995664	·30	152363	15·11	847637	55
6	148915	14·78	995646	·30	153269	15·08	846731	54
7	149802	14·75	995628	·30	154174	15·05	845826	53
8	150686	14·72	995610	·30	155077	15·02	844923	52
9	151569	14·69	995591	·30	155978	14·99	844022	51
10	152451	14·66	995573	·30	156877	14·96	843123	50
11	9·1 3330	14·63	9·995555	·30	9·157775	14·93	10·842225	49
12	154208	14·60	995537	·30	158671	14·90	841329	48
13	155083	14·57	995519	·30	159565	14·87	840435	47
14	155957	14·54	995501	·31	160457	14·84	839543	46
15	156830	14·51	995482	·31	161347	14·81	838653	45
16	157700	14·48	995464	·31	162236	14·79	837764	44
17	158569	14·45	995446	·31	163123	14·76	836877	43
18	159435	14·42	995427	·31	164008	14·73	835992	42
19	160301	14·39	995409	·31	164892	14·70	835108	41
20	161164	14·36	995390	·31	165774	14·67	834226	40
21	9·162025	14·33	9·995372	·31	9·166654	14·64	10·833346	39
22	162885	14·30	995353	·31	167532	14·61	832468	38
23	163743	14·27	995334	·31	168409	14·58	831591	37
24	164600	14·24	995316	·31	169284	14·55	830716	36
25	165454	14·22	995297	·31	170157	14·53	829843	35
26	166307	14·19	995278	·31	171029	14·50	828971	34
27	167159	14·16	995260	·31	171899	14·47	828101	33
28	168008	14·13	995241	·32	172767	14·44	827233	32
29	168856	14·10	995222	·32	173634	14·42	826366	31
30	169702	14·07	995203	·32	174499	14·39	825501	30
31	9·170547	14·05	9·995184	·32	9·175362	14·36	10·824638	29
32	171389	14·02	995165	·32	176224	14·33	823776	28
33	172230	13·99	995146	·32	177084	14·31	822916	27
34	173070	13·96	995127	·32	177942	14·28	822058	26
35	173908	13·94	995108	·32	178799	14·25	821201	25
36	174744	13·91	995089	·32	179655	14·23	820345	24
37	175578	13·88	995070	·32	180508	14·20	819492	23
38	176411	13·86	995051	·32	181360	14·17	818640	22
39	177242	13·83	995032	·32	182211	14·15	817789	21
40	178072	13·80	995013	·32	183059	14·12	816941	20
41	9·178900	13·77	9·994993	·32	9·183907	14·09	10·816093	19
42	179726	13·74	994974	·32	184752	14·07	815248	18
43	180551	13·72	994955	·32	185597	14·04	814403	17
44	181374	13·69	994935	·32	186439	14·02	813561	16
45	182196	13·66	994916	·33	187280	13·99	812720	15
46	183016	13·64	994896	·33	188120	13·96	811880	14
47	183834	13·61	994877	·33	188958	13·93	811042	13
48	184651	13·58	994857	·33	189794	13·91	810206	12
49	185466	13·56	994838	·33	190629	13·89	809371	11
50	186280	13·53	994818	·33	191462	13·86	808538	10
51	9·187092	13·51	9·994798	·33	9·192294	13·84	10·807706	9
52	187903	13·48	994779	·33	193124	13·81	806876	8
53	188712	13·46	994759	·33	193953	13·79	806047	7
54	189519	13·43	994739	·33	194780	13·76	805220	6
55	190325	13·41	994719	·33	195606	13·74	804394	5
56	191130	13·38	994700	·33	196430	13·71	803570	4
57	191933	13·36	994680	·33	197253	13·69	802747	3
58	192734	13·33	994660	·33	198074	13·66	801926	2
59	193534	13·30	994640	·33	198894	13·64	801106	1
60	194332	13·28	994620	·33	199713	13·61	800287	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·194332	13·28	9·994620	·33	9·199713	13·61	10·800287	60
1	195129	13·26	994600	·33	200529	13·59	799471	59
2	195925	13·23	994580	·33	201345	13·56	798655	58
3	196719	13·21	994560	·34	202159	13·54	797841	57
4	197511	13·18	994540	·34	202971	13·52	797029	56
5	198302	13·16	994519	·34	203782	13·49	796218	55
6	199091	13·13	994499	·34	204592	13·47	795408	54
7	199879	13·11	994479	·34	205400	13·45	794600	53
8	200666	13·08	994459	·34	206207	13·42	793793	52
9	201451	13·06	994438	·34	207013	13·40	792987	51
10	202234	13·04	994418	·34	207817	13·38	792183	50
11	9·203017	13·01	9·994397	·34	9·208619	13·35	10·791381	49
12	203797	12·99	994377	·34	209420	13·33	790580	48
13	204577	12·96	994357	·34	210220	13·31	789780	47
14	205354	12·94	994336	·34	211018	13·28	788982	46
15	206131	12·92	994316	·34	211815	13·26	788185	45
16	206906	12·89	994295	·34	212611	13·24	787389	44
17	207679	12·87	994274	·35	213405	13·21	786595	43
18	208452	12·85	994254	·35	214198	13·19	785802	42
19	209222	12·82	994233	·35	214989	13·17	785011	41
20	209992	12·80	994212	·35	215780	13·15	784220	40
21	9·210760	12·78	9·994191	·35	9·216568	13·12	10·783432	39
22	211526	12·75	994171	·35	217356	13·10	782644	38
23	212291	12·73	994150	·35	218142	13·08	781858	37
24	213055	12·71	994129	·35	218926	13·05	781074	36
25	213818	12·68	994108	·35	219710	13·03	780290	35
26	214579	12·66	994087	·35	220492	13·01	779508	34
27	215338	12·64	994066	·35	221272	12·99	778728	33
28	216097	12·61	994045	·35	222052	12·97	777948	32
29	216854	12·59	994024	·35	222830	12·94	777170	31
30	217609	12·57	994003	·35	223606	12·92	776394	30
31	9·218363	12·55	9·993981	·35	9·224382	12·90	10·775618	29
32	219116	12·53	993960	·35	225156	12·88	774844	28
33	219868	12·50	993939	·35	225929	12·86	774071	27
34	220618	12·48	993918	·35	226700	12·84	773300	26
35	221367	12·46	993896	·36	227471	12·81	772529	25
36	222115	12·44	993875	·36	228239	12·79	771761	24
37	222861	12·42	993854	·36	229007	12·77	770993	23
38	223606	12·39	993832	·36	229773	12·75	770227	22
39	224349	12·37	993811	·36	230539	12·73	769461	21
40	225092	12·35	993789	·36	231302	12·71	768698	20
41	9·225833	12·33	9·993768	·36	9·232065	12·69	10·767935	19
42	226573	12·31	993746	·36	232826	12·67	767174	18
43	227311	12·28	993725	·36	233586	12·65	766414	17
44	228048	12·26	993703	·36	234345	12·62	765655	16
45	228784	12·24	993681	·36	235103	12·60	764897	15
46	229518	12·22	993660	·36	235859	12·58	764141	14
47	230252	12·20	993638	·36	236614	12·56	763386	13
48	230984	12·18	993616	·36	237368	12·54	762632	12
49	231714	12·16	993594	·37	238120	12·52	761880	11
50	232444	12·14	993572	·37	238872	12·50	761128	10
5.	9·233172	12·12	9·993550	·37	9·239622	12·48	10·760378	9
52	233899	12·09	993528	·37	240371	12·46	759629	8
53	234625	12·07	993506	·37	241118	12·44	758882	7
54	235349	12·05	993484	·37	241865	12·42	758135	6
55	236073	12·03	993462	·37	242610	12·40	757390	5
56	236795	12·01	993440	·37	243354	12·38	756646	4
57	237515	11·99	993418	·37	244097	12·36	755903	3
58	238235	11·97	993396	·37	244839	12·34	755161	2
59	238953	11·95	993374	·37	245579	12·32	754421	1
60	239670	11·93	993351	·37	246319	12·30	753681	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(80 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·239670	11·93	9·993351	·37	9·246319	12·30	10·753681	60
1	240386	11·91	993329	·37	247057	12·28	752943	59
2	241101	11·89	993307	·37	247794	12·26	752206	58
3	241814	11·87	993285	·37	248530	12·24	751470	57
4	242526	11·85	993262	·37	249264	12·22	750736	56
5	243237	11·83	993240	·37	249998	12·20	750002	55
6	243947	11·81	993217	·38	250730	12·18	749270	54
7	244656	11·79	993195	·38	251461	12·17	748539	53
8	245363	11·77	993172	·38	252191	12·15	747809	52
9	246069	11·75	993149	·38	252920	12·13	747080	51
10	246775	11·73	993127	·38	253648	12·11	746352	50
11	9·247478	11·71	9·993104	·38	9·254374	12·09	10·745626	49
12	248181	11·69	993081	·38	255100	12·07	744900	48
13	248883	11·67	993059	·38	255824	12·05	744176	47
14	249583	11·65	993036	·38	256547	12·03	743453	46
15	250282	11·63	993013	·38	257269	12·01	742731	45
16	250980	11·61	992990	·38	257990	12·00	742010	44
17	251677	11·59	992967	·38	258710	11·98	741290	43
18	252373	11·58	992944	·38	259429	11·96	740571	42
19	253067	11·56	992921	·38	260146	11·94	739854	41
20	253761	11·54	992898	·38	260863	11·92	739137	40
21	9·254453	11·52	9·992875	·38	9·261578	11·90	10·738422	39
22	255144	11·50	992852	·38	262292	11·89	737708	38
23	255834	11·48	992829	·39	263005	11·87	736995	37
24	256523	11·46	992806	·39	263717	11·85	736283	36
25	257211	11·44	992783	·39	264428	11·83	735572	35
26	257898	11·42	992759	·39	265138	11·81	734862	34
27	258583	11·41	992736	·39	265847	11·79	734153	33
28	259268	11·39	992713	·39	266555	11·78	733445	32
29	259951	11·37	992690	·39	267261	11·76	732739	31
30	260633	11·35	992666	·39	267967	11·74	732033	30
31	9·261314	11·33	9·992643	·39	9·268671	11·72	10·731329	29
32	261994	11·31	992619	·39	269375	11·70	730625	28
33	262673	11·30	992596	·39	270077	11·69	729923	27
34	263351	11·28	992572	·39	270779	11·67	729221	26
35	264027	11·26	992549	·39	271479	11·65	728521	25
36	264703	11·24	992525	·39	272178	11·64	727822	24
37	265377	11·22	992501	·39	272876	11·62	727124	23
38	266051	11·20	992478	·40	273573	11·60	726427	22
39	266723	11·19	992454	·40	274269	11·58	725731	21
40	267395	11·17	992430	·40	274964	11·57	725036	20
41	9·268065	11·15	9·992406	·40	9·275658	11·55	10·724342	19
42	268734	11·13	992382	·40	276351	11·53	723649	18
43	269402	11·11	992359	·40	277043	11·51	722957	17
44	270069	11·10	992335	·40	277734	11·50	722266	16
45	270735	11·08	992311	·40	278424	11·48	721576	15
46	271400	11·06	992287	·40	279113	11·47	720887	14
47	272064	11·05	992263	·40	279801	11·45	720199	13
48	272726	11·03	992239	·40	280488	11·43	719512	12
49	273388	11·01	992214	·40	281174	11·41	718826	11
50	274049	10·99	992190	·40	281858	11·40	718142	10
51	9·274708	10·98	9·992166	·40	9·282542	11·38	10·717458	9
52	275367	10·96	992142	·40	283225	11·36	716775	8
53	276024	10·94	992117	·41	283907	11·35	716093	7
54	276681	10·92	992093	·41	284588	11·33	715412	6
55	277337	10·91	992069	·41	285268	11·31	714732	5
56	277991	10·89	992044	·41	285947	11·30	714053	4
57	278644	10·87	992020	·41	286624	11·28	713376	3
58	279297	10·86	991996	·41	287301	11·26	712699	2
59	279948	10·84	991971	·41	287977	11·25	712023	1
60	280599	10·82	991947	·41	288652	11·23	711348	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(79 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·280599	10·82	9·991947	·41	9·288652	11·23	10·711348	60
1	281248	10·81	991922	·41	289326	11·22	710674	59
2	281897	10·79	991897	·41	289999	11·20	710001	58
3	282544	10·77	991873	·41	290671	11·18	709329	57
4	283190	10·76	991848	·41	291342	11·17	708658	56
5	283836	10·74	991823	·41	292013	11·16	707987	55
6	284480	10·72	991799	·41	292682	11·14	707318	54
7	285124	10·71	991774	·42	293350	11·12	706650	53
8	385766	10·69	991749	·42	294017	11·11	705983	52
9	286408	10·67	991724	·42	294684	11·09	705316	51
10	287048	10·66	991699	·42	295349	11·07	704651	50
11	9·287687	10·64	9·991674	·42	9·296013	11·06	10·703987	49
12	288326	10·63	991649	·42	296677	11·04	703323	48
13	288964	10·61	991624	·42	297339	11·03	702661	47
14	289600	10·59	991599	·42	298001	11·01	701999	46
15	290236	10·58	991574	·42	298662	11·00	701338	45
16	290870	10·56	991549	·42	299322	10·98	700678	44
17	291504	10·54	991524	·42	299980	10·96	700020	43
18	292137	10·53	991498	·42	300638	10·95	699362	42
19	292768	10·51	991473	·42	301295	10·93	698705	41
20	293399	10·50	991448	·42	301951	10·92	698049	40
21	9·294029	10·48	9·991422	·42	9·302607	10·90	10·697393	39
22	294658	10·46	991397	·42	303261	10·89	696739	38
23	295286	10·45	991372	·43	303914	10·87	696086	37
24	295913	10·43	991346	·43	304567	10·86	695433	36
25	296539	10·42	991321	·43	305218	10·84	694782	35
26	297164	10·40	991295	·43	305869	10·83	694131	34
27	297788	10·39	991270	·43	306519	10·81	693481	33
28	298412	10·37	991244	·43	307168	10·80	692832	32
29	299034	10·36	991218	·43	307815	10·78	692185	31
30	299655	10·34	991193	·43	308463	10·77	691537	30
31	9·300276	10·32	9·991167	·43	9·309109	10·75	10·690891	29
32	300895	10·31	991141	·43	309754	10·74	690246	28
33	301514	10·29	991115	·43	310398	10·73	689602	27
34	302132	10·28	991090	·43	311042	10·71	688958	26
35	302748	10·26	991064	·43	311685	10·70	688315	25
36	303364	10·25	991038	·43	312327	10·68	687673	24
37	303979	10·23	991012	·43	312967	10·67	687033	23
38	304593	10·22	990986	·43	313608	10·65	686392	22
39	305207	10·20	990960	·43	314247	10·64	685753	21
40	305819	10·19	990934	·44	314885	10·62	685115	20
41	9·306430	10·17	9·990908	·44	9·315523	10·61	10·684477	19
42	307041	10·16	990882	·44	316159	10·60	683841	18
43	307650	10·14	990855	·44	316795	10·58	683205	17
44	308259	10·13	990829	·44	317430	10·57	682570	16
45	308867	10·11	990803	·44	318064	10·55	681936	15
46	309474	10·10	990777	·44	318697	10·54	681303	14
47	310080	10·08	990750	·44	319329	10·53	680671	13
48	310685	10·07	990724	·44	319961	10·51	680039	12
49	311289	10·05	990697	·44	320592	10·50	679408	11
50	311893	10·04	990671	·44	321222	10·48	678778	10
51	9·312495	10·03	9·990644	·44	9·321851	10·47	10·678149	9
52	313097	10·01	990618	·44	322479	10·45	677521	8
53	313698	10·00	990591	·44	323106	10·44	676894	7
54	314297	9·98	990565	·44	323733	10·43	676267	6
55	314897	9·97	990538	·44	324358	10·41	675642	5
56	315495	9·96	990511	·45	324983	10·40	675017	4
57	316092	9·94	990485	·45	325607	10·39	674393	3
58	316689	9·93	990458	·45	326231	10·37	673769	2
59	317284	9·91	990431	·45	326853	10·36	673147	1
60	317879	9·90	990404	·45	327475	10·35	672525	0
	Cosine	D.	Sine		Cotang.	D.	Tang	M.

(78 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·317879	9·90	9·990404	·45	9·327474	10·35	10·672526	60
1	318473	9·88	990378	·45	328095	10·33	671905	59
2	319066	9·87	990351	·45	328715	10·32	671285	58
3	319658	9·86	990324	·45	329334	10·30	670666	57
4	320249	9·84	990297	·45	329953	10·29	670047	56
5	320840	9·83	990270	·45	330570	10·28	669430	55
6	321430	9·82	990243	·45	331187	10·26	668813	54
7	322019	9·80	990215	·45	331803	10·25	668197	53
8	322607	9·79	990188	·45	332418	10·24	667582	52
9	323194	9·77	990161	·45	333033	10·23	666967	51
10	323780	9·76	990134	·45	333646	10·21	666354	50
11	9·324366	9·75	9·990107	·46	9·334259	10·20	10·665741	49
12	324950	9·73	990079	·46	334871	10·19	665129	48
13	325534	9·72	990052	·46	335482	10·17	664518	47
14	326117	9·70	990025	·46	336093	10·16	663907	46
15	326700	9·69	989997	·46	336702	10·15	663298	45
16	327281	9·68	989970	·46	337311	10·13	662689	44
17	327862	9·66	989942	·46	337919	10·12	662081	43
18	328442	9·65	989915	·46	338527	10·11	661473	42
19	329021	9·64	989887	·46	339133	10·10	660867	41
20	329599	9·62	989860	·46	339739	10·08	660261	40
21	9·330176	9·61	9·989832	·46	9·340344	10·07	10·659656	39
22	330753	9·60	989804	·46	340948	10·06	659052	38
23	331329	9·58	989777	·46	341552	10·04	658448	37
24	331903	9·57	989749	·47	342155	10·03	657845	36
25	332478	9·56	989721	·47	342757	10·02	657243	35
26	333051	9·54	989693	·47	343358	10·00	656642	34
27	333624	9·53	989665	·47	343958	9·99	656042	33
28	334195	9·52	989637	·47	344558	9·98	655442	32
29	334766	9·50	989609	·47	345157	9·97	654843	31
30	335337	9·49	989582	·47	345755	9·96	654245	30
31	9·335906	9·48	9·989553	·47	9·346353	9·94	10·653647	29
32	336475	9·46	989525	·47	346949	9·93	653051	28
33	337043	9·45	989497	·47	347545	9·92	652455	27
34	337610	9·44	989469	·47	348141	9·91	651859	26
35	338176	9·43	989441	·47	348735	9·90	651265	25
36	338742	9·41	989413	·47	349329	9·88	650671	24
37	339306	9·40	989384	·47	349922	9·87	650078	23
38	339871	9·39	989356	·47	350514	9·86	649486	22
39	340434	9·37	989328	·47	351106	9·85	648894	21
40	340996	9·36	989300	·47	351697	9·83	648303	20
41	9·341558	9·35	9·989271	·47	9·352287	9·82	10·647713	19
42	342119	9·34	989243	·47	352876	9·81	647124	18
43	342679	9·32	989214	·47	353465	9·80	646535	17
44	343239	9·31	989186	·47	354053	9·79	645947	16
45	343797	9·30	989157	·47	354640	9·77	645360	15
46	344355	9·29	989128	·48	355227	9·76	644773	14
47	344912	9·27	989100	·48	355813	9·75	644187	13
48	345469	9·26	989071	·48	356398	9·74	643602	12
49	346024	9·25	989042	·48	356982	9·73	643018	11
50	346579	9·24	989014	·48	357566	9·71	642434	10
51	9·347134	9·22	9·988985	·48	9·358149	9·70	10·641851	9
52	347687	9·21	988956	·48	358731	9·69	641269	8
53	348240	9·20	988927	·48	359313	9·68	640687	7
54	348792	9·19	988898	·48	359893	9·67	640107	6
55	349343	9·17	988869	·48	360474	9·66	639526	5
56	349893	9·16	988840	·48	361053	9·65	638947	4
57	350443	9·15	988811	·49	361632	9·63	638368	3
58	350992	9·14	988782	·49	362210	9·62	637790	2
59	351540	9·13	988753	·49	362787	9·61	637213	1
60	352088	9·11	988724	·49	363364	9·60	636636	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(77 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·352088	9·11	9·988724	·49	9·363364	9·60	10·636636	60
1	352635	9·10	988695	·49	363940	9·59	636060	59
2	353181	9·09	988666	·49	364515	9·58	635485	58
3	353726	9·08	988636	·49	365090	9·57	634910	57
4	354271	9·07	988607	·49	365664	9·55	634336	56
5	354815	9·05	988578	·49	366237	9·54	633763	55
6	355358	9·04	988548	·49	366810	9·53	633190	54
7	355901	9·03	988519	·49	367382	9·52	632618	53
8	356443	9·02	988489	·49	367953	9·51	632047	52
9	356984	9·01	988460	·49	368524	9·50	631476	51
10	357524	8·99	988430	·49	369094	9·49	630906	50
11	9·358064	8·98	9·988401	·49	9·369663	9·48	10·630337	49
12	358603	8·97	988371	·49	370232	9·46	629768	48
13	359141	8·96	988342	·49	370799	9·45	629201	47
14	359678	8·95	988312	·50	371367	9·44	628633	46
15	360215	8·93	988282	·50	371933	9·43	628067	45
16	360752	8·92	988252	·50	372499	9·42	627501	44
17	361287	8·91	988223	·50	373064	9·41	626936	43
18	361822	8·90	988193	·50	373629	9·40	626371	42
19	362356	8·89	988163	·50	374193	9·39	625807	41
20	362889	8·88	988133	·50	374756	9·38	625244	40
21	9·363422	8·87	9·988103	·50	9·375319	9·37	10·624681	39
22	363954	8·85	988073	·50	375881	9·35	624119	38
23	364485	8·84	988043	·50	376442	9·34	623558	37
24	365016	8·83	988013	·50	377003	9·33	622997	36
25	355546	8·82	987983	·50	377563	9·32	622437	35
26	366075	8·81	987953	·50	378122	9·31	621878	34
27	366604	8·80	987922	·50	378681	9·30	621319	33
28	367131	8·79	987892	·50	379239	9·29	620761	32
29	367659	8·77	987862	·50	379797	9·28	620203	31
30	368185	8·76	987832	·51	380354	9·27	619646	30
31	9·368711	8·75	9·987801	·51	9·380910	9·26	10·619090	29
32	369236	8·74	987771	·51	381466	9·25	618534	28
33	369761	8·73	987740	·51	382020	9·24	617980	27
34	370285	8·72	987710	·51	382575	9·23	617425	26
35	370808	8·71	987679	·51	383129	9·22	616871	25
36	371330	8·70	987649	·51	383682	9·21	616318	24
37	371852	8·69	987618	·51	384234	9·20	615766	23
38	372373	8·67	987588	·51	384786	9·19	615214	22
39	372894	8·66	987557	·51	385337	9·18	614663	21
40	373414	8·65	987526	·51	385888	9·17	614112	20
41	9·373933	8·64	9·987496	·51	9·386438	9·15	10·613562	19
42	374452	8·63	987465	·51	386987	9·14	613013	18
43	374970	8·62	987434	·51	387536	9·13	612464	17
44	375487	8·61	987403	·52	388084	9·12	611916	16
45	376003	8·60	987372	·52	388631	9·11	611369	15
46	376519	8·59	987341	·52	389178	9·10	610822	14
47	377035	8·58	987310	·52	389724	9·09	610276	13
48	377549	8·57	987279	·52	390270	9·08	609730	12
49	378063	8·56	987248	·52	390815	9·07	609185	11
50	378577	8·54	987217	·52	391360	9·06	608640	10
51	9·370089	8·53	9·987186	·52	9·391903	9·05	10·608097	9
52	379601	8·52	987155	·52	392447	9·04	607553	8
53	380113	8·51	987124	·52	392989	9·03	607011	7
54	380624	8·50	987092	·52	393531	9·02	606469	6
55	381134	8·49	987061	·52	394073	9·01	605927	5
56	381643	8·48	987030	·52	394614	9·00	605386	4
57	382152	8·47	986998	·52	395154	8·99	604846	3
58	382661	8·46	986967	·52	395694	8·98	604306	2
59	383168	8·45	986936	·52	396233	8·97	603767	1
60	383675	8·44	986904	·52	396771	8·96	603229	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·383675	8·44	9·986904	·52	9·396771	8·96	10·603229	60
1	384182	8·43	986873	·53	397309	8·96	602691	59
2	384687	8·42	986841	·53	397846	8·95	602154	58
3	385192	8·41	986809	·53	398383	8·94	601617	57
4	385697	8·40	986778	·53	398919	8·93	601081	56
5	386201	8·39	986746	·53	399455	8·93	600545	55
6	386704	8·38	986714	·53	399990	8·91	600010	54
7	387207	8·37	986683	·53	400524	8·90	599476	53
8	387709	8·36	986651	·53	401058	8·89	598942	52
9	388210	8·35	986619	·53	401591	8·88	598409	51
10	388711	8·34	986587	·53	402124	8·87	597876	50
11	9·389211	8·33	9·986555	·53	9·402656	8·86	10·597344	49
12	389711	8·32	986523	·53	403187	8·85	596813	48
13	390210	8·31	986491	·53	403718	8·84	596282	47
14	390708	8·30	986459	·53	404249	8·83	595751	46
15	391206	8·28	986427	·53	404778	8·82	595222	45
16	391703	8·27	986395	·53	405308	8·81	594692	44
17	392199	8·26	986363	·54	405836	8·80	594164	43
18	392695	8·25	986331	·54	406364	8·79	593636	42
19	393191	8·24	986299	·54	406892	8·78	593108	41
20	393685	8·23	986266	·54	407419	8·77	592581	40
21	9·394179	8·22	9·986234	·54	9·407945	8·76	10·592055	39
22	394673	8·21	986202	·54	408471	8·75	591529	38
23	395166	8·20	986169	·54	408997	8·74	591003	37
24	395658	8·19	986137	·54	409521	8·74	590479	36
25	396150	8·18	986104	·54	410045	8·73	589955	35
26	396641	8·17	986072	·54	410569	8·72	589431	34
27	397132	8·17	986039	·54	411092	8·71	588908	33
28	397621	8·16	986007	·54	411615	8·70	588385	32
29	398111	8·15	985974	·54	412137	8·69	587863	31
30	398600	8·14	985942	·54	412658	8·68	587342	30
31	9·399088	8·13	9·985909	·55	9·413179	8·67	10·586821	29
32	399575	8·12	985876	·55	413699	8·66	586301	28
33	400062	8·11	985843	·55	414219	8·65	585781	27
34	400549	8·10	985811	·55	414738	8·64	585262	26
35	401035	8·09	985778	·55	415257	8·64	584743	25
36	401520	8·08	985745	·55	415775	8·63	584225	24
37	402005	8·07	985712	·55	416293	8·62	583707	23
38	402489	8·06	985679	·55	416810	8·61	583190	22
39	402972	8·05	985646	·55	417326	8·60	582674	21
40	403455	8·04	985613	·55	417842	8·59	582158	20
41	9·403938	8·03	9·985580	·55	9·418358	8·58	10·581642	19
42	404420	8·02	985547	·55	418873	8·57	581127	18
43	404901	8·01	985514	·55	419387	8·56	580613	17
44	405382	8·00	985480	·55	419901	8·55	580099	16
45	405862	7·99	985447	·55	420415	8·55	579585	15
46	406341	7·98	985414	·56	420927	8·54	579073	14
47	406820	7·97	985380	·56	421440	8·53	578560	13
48	407299	7·96	985347	·56	421952	8·52	578048	12
49	407777	7·95	985314	·56	422463	8·51	577537	11
50	408254	7·94	985280	·56	422974	8·50	577026	10
51	9·408731	7·94	9·985247	·56	9·423484	8·49	10·576516	9
52	409207	7·93	985213	·56	423993	8·48	576007	8
53	409682	7·92	985180	·56	424503	8·48	575497	7
54	410157	7·91	985146	·56	425011	8·47	574989	6
55	410632	7·90	985113	·56	425519	8·46	574481	5
56	411106	7·89	985079	·56	426027	8·45	573973	4
57	411579	7·88	985045	·56	426534	8·44	573466	3
58	412052	7·87	985011	·56	427041	8·43	572959	2
59	412524	7·86	984978	·56	427547	8·43	572453	1
60	412996	7·85	984944	·56	428052	8·42	571948	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(75 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·412996	7·85	9·984944	·57	9·428052	8·42	10·571948	60
1	413467	7·84	984910	·57	428557	8·41	571443	59
2	413938	7·83	984876	·57	429062	8·40	570938	58
3	414408	7·83	984842	·57	429566	8·39	570434	57
4	414878	7·82	984808	·57	430070	8·38	569930	56
5	415347	7·81	984774	·57	430573	8·38	569427	55
6	415815	7·80	984740	·57	431075	8·37	568925	54
7	416283	7·79	984706	·57	431577	8·36	568423	53
8	416751	7·78	984672	·57	432079	8·35	567921	52
9	417217	7·77	984637	·57	432580	8·34	567420	51
10	417684	7·76	984603	·57	433080	8·33	566920	50
11	9·418150	7·75	9·984569	·57	9·433580	8·32	10·566420	49
12	418615	7·74	984535	·57	434080	8·32	565920	48
13	419079	7·73	984500	·57	434579	8·31	565421	47
14	419544	7·73	984466	·57	435078	8·30	564922	46
15	420007	7·72	984432	·58	435576	8·29	564424	45
16	420470	7·71	984397	·58	436073	8·28	563927	44
17	420933	7·70	984363	·58	436570	8·28	563430	43
18	421395	7·69	984328	·58	437067	8·27	562933	42
19	421857	7·68	984294	·58	437563	8·26	562437	41
20	422318	7·67	984259	·58	438059	8·25	561941	40
21	9·422778	7·67	9·984224	·58	9·438554	8·24	10·561446	39
22	423238	7·66	984190	·58	439048	8·23	560952	38
23	423697	7·65	984155	·58	439543	8·23	560457	37
24	424156	7·64	984120	·58	440036	8·22	559964	36
25	424615	7·63	984085	·58	440529	8·21	559471	35
26	425073	7·62	984050	·58	441022	8·20	558978	34
27	425530	7·61	984015	·58	441514	8·19	558486	33
28	425987	7·60	983981	·58	442006	8·19	557994	32
29	426443	7·60	983946	·58	442497	8·18	557503	31
30	426899	7·59	983911	·58	442988	8·17	557012	30
31	9·427354	7·58	9·983875	·58	9·443479	8·16	10·556521	29
32	427809	7·57	983840	·59	443968	8·16	556032	28
33	428263	7·56	983805	·59	444458	8·15	555542	27
34	428717	7·55	983770	·59	444947	8·14	555053	26
35	429170	7·54	983735	·59	445435	8·13	554565	25
36	429623	7·53	983700	·59	445923	8·12	554077	24
37	430075	7·52	983664	·59	446411	8·12	553589	23
38	430527	7·52	983629	·59	446898	8·11	553102	22
39	430978	7·51	983594	·59	447384	8·10	552616	21
40	431429	7·50	983558	·59	447870	8·09	552130	20
41	9·431879	7·49	9·983523	·59	9·448356	8·09	10·551644	19
42	432329	7·49	983487	·59	448841	8·08	551159	18
43	432778	7·48	983452	·59	449326	8·07	550674	17
44	433226	7·47	983416	·59	449810	8·06	550190	16
45	433675	7·46	983381	·59	450294	8·06	549706	15
46	434122	7·45	983345	·59	450777	8·05	549223	14
47	434569	7·44	983309	·59	451260	8·04	548740	13
48	435016	7·44	983273	·60	451743	8·03	548257	12
49	435462	7·43	983238	·60	452225	8·02	547775	11
50	435908	7·42	983202	·60	452706	8·02	547294	10
51	9·436353	7·41	9·983166	·60	9·453187	8·01	10·546813	9
52	436798	7·40	983130	·60	453668	8·00	546332	8
53	437242	7·40	983094	·60	454148	7·99	545852	7
54	437686	7·39	983058	·60	454628	7·99	545372	6
55	438129	7·38	983022	·60	455107	7·98	544893	5
56	438572	7·37	982986	·60	455586	7·97	544414	4
57	439014	7·36	982950	·60	456064	7·96	543936	3
58	439456	7·36	982914	·60	456542	7·96	543458	2
59	439897	7·35	982878	·60	457019	7·95	542981	1
60	440338	7·34	982842	·60	457496	7·94	542504	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(74 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·440338	7·34	9·982842	·60	9·457496	7·94	10·542504	60
1	440778	7·33	982805	·60	457973	7·93	542027	59
2	441218	7·32	982769	·61	458449	7·93	541551	58
3	441658	7·31	982733	·61	458925	7·92	541075	57
4	442096	7·31	982696	·61	459400	7·91	540600	56
5	442535	7·30	982660	·61	459875	7·90	540125	55
6	442973	7·29	982624	·61	460349	7·90	539651	54
7	443410	7·28	982587	·61	460823	7·89	539177	53
8	443847	7·27	982551	·61	461297	7·88	538703	52
9	444284	7·27	982514	·61	461770	7·88	538230	51
10	444720	7·26	982477	·61	462242	7·87	537758	50
11	9·445155	7·25	9·982441	·61	9·462714	7·86	10·537286	49
12	445590	7·24	982404	·61	463186	7·85	536814	48
13	446025	7·23	982367	·61	463658	7·85	536342	47
14	446459	7·23	982331	·61	464129	7·84	535871	46
15	446893	7·22	982294	·61	464599	7·83	535401	45
16	447326	7·21	982257	·61	465069	7·83	534931	44
17	447759	7·20	982220	·62	465539	7·82	534461	43
18	448191	7·20	982183	·62	466008	7·81	533992	42
19	448623	7·19	982146	·62	466476	7·80	533524	41
20	449054	7·18	982109	·62	466945	7·80	533055	40
21	9·449485	7·17	9·982072	·62	9·467413	7·79	10·532587	39
22	449915	7·16	982035	·62	467880	7·78	532120	38
23	450345	7·16	981998	·62	468347	7·78	531653	37
24	450775	7·15	981961	·62	468814	7·77	531186	36
25	451204	7·14	981924	·62	469280	7·76	530720	35
26	451632	7·13	981886	·62	469746	7·75	530254	34
27	452060	7·13	981849	·62	470211	7·75	529789	33
28	452488	7·12	981812	·62	470676	7·74	529324	32
29	452915	7·11	981774	·62	471141	7·73	528859	31
30	453342	7·10	981737	·62	471605	7·73	528395	30
31	9·453768	7·10	9·981699	·63	9·472068	7·72	10·527932	29
32	454194	7·09	981662	·63	472532	7·71	527468	28
33	454619	7·08	981625	·63	472995	7·71	527005	27
34	455044	7·07	981587	·63	473457	7·70	526543	26
35	455469	7·07	981549	·63	473919	7·69	526081	25
36	455893	7·06	981512	·63	474381	7·69	525619	24
37	456316	7·05	981474	·63	474842	7·68	525158	23
38	456739	7·04	981436	·63	475303	7·67	524697	22
39	457162	7·04	981399	·63	475763	7·67	524237	21
40	457584	7·03	981361	·63	476223	7·66	523777	20
41	9·458006	7·02	9·981323	·63	9·476683	7·65	10·523317	19
42	458427	7·01	981285	·63	477142	7·65	522858	18
43	458848	7·01	981247	·63	477601	7·64	522399	17
44	459268	7·00	981209	·63	478059	7·63	521941	16
45	459688	6·99	981171	·63	478517	7·63	521483	15
46	460108	6·98	981133	·64	478975	7·62	521025	14
47	460527	6·98	981095	·64	479432	7·61	520568	13
48	460946	6·97	981057	·64	479889	7·61	520111	12
49	461364	6·96	981019	·64	480345	7·60	519655	11
50	461782	6·95	980981	·64	480801	7·59	519199	10
51	9·462199	6·95	9·980942	·64	9·481257	7·59	10·518743	9
52	462616	6·94	980904	·64	481712	7·58	518288	8
53	463032	6·93	980866	·64	482167	7·57	517833	7
54	463448	6·93	980827	·64	482621	7·57	517379	6
55	463864	6·92	980789	·64	483075	7·56	516925	5
56	464279	6·91	980750	·64	483529	7·55	516471	4
57	464694	6·90	980712	·64	483982	7·55	516018	3
58	465108	6·90	980673	·64	484435	7·54	515565	2
59	465522	6·89	980635	·64	484887	7·53	515113	1
60	465935	6·88	980596	·64	485339	7·53	514661	0
	Cosine	D.	Sine		Cotang.	D.	Tang.	M.

(73 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·465935	6·88	9·980596	·64	9·485339	7·55	10·514661	60
1	466348	6·88	980558	·64	485791	7·52	514209	59
2	466761	6·87	980519	·65	486242	7·51	513758	58
3	467173	6·86	980480	·65	486693	7·51	513307	57
4	467585	6·85	980442	·65	487143	7·50	512857	56
5	467996	6·85	980403	·65	487593	7·49	512407	55
6	468407	6·84	980364	·65	488043	7·49	511957	54
7	468817	6·83	980325	·65	488492	7·48	511508	53
8	469227	6·83	980286	·65	488941	7·47	511059	52
9	469637	6·82	980247	·65	489390	7·47	510610	51
10	470046	6·81	980208	·65	489838	7·46	510162	50
11	9·470455	6·80	9·980169	·65	9·490286	7·46	10·509714	49
12	470863	6·80	980130	·65	490733	7·45	509267	48
13	471271	6·79	980091	·65	491180	7·44	508820	47
14	471679	6·78	980052	·65	491627	7·44	508373	46
15	472086	6·78	980012	·65	492073	7·43	507927	45
16	472492	6·77	979973	·65	492519	7·43	507481	44
17	472898	6·76	979934	·66	492965	7·42	507035	43
18	473304	6·76	979895	·66	493410	7·41	506590	42
19	473710	6·75	979855	·66	493854	7·40	506146	41
20	474115	6·74	979816	·66	494299	7·40	505701	40
21	9·474519	6·74	9·979776	·66	9·494743	7·40	10·505257	39
22	474923	6·73	979737	·66	495186	7·39	504814	38
23	475327	6·72	979697	·66	495630	7·38	504370	37
24	475730	6·72	979658	·56	496073	7·37	503927	36
25	476133	6·71	979618	·66	496515	7·37	503485	35
26	476536	6·70	979579	·66	496957	7·36	503043	34
27	476938	6·69	979539	·66	497399	7·36	502601	33
28	477340	6·69	979499	·66	497841	7·35	502159	32
29	477741	6·68	979459	·66	498282	7·34	501718	31
30	478142	6·67	979420	·66	498722	7·34	501278	30
31	9·478542	6·67	9·979380	·66	9·499163	7·33	10·500837	29
32	478942	6·66	979340	·66	499603	7·33	500397	28
33	479342	6·65	979300	·67	500042	7·32	499958	27
34	479741	6·65	979260	·67	500481	7·31	499519	26
35	480140	6·64	979220	·67	500920	7·31	499080	25
36	480539	6·63	979180	·67	501359	7·30	498641	24
37	480937	6·63	979140	·67	501797	7·30	498203	23
38	481334	6·62	979100	·67	502235	7·29	497765	22
39	481731	6·61	979059	·67	502672	7·28	497328	21
40	482128	6·61	979019	·67	503109	7·28	496891	20
41	9·482525	6·60	9·978979	·67	9·503546	7·27	10·496454	19
42	482921	6·59	978939	·67	503982	7·27	496018	18
43	483316	6·59	978898	·67	504418	7·26	495582	17
44	483712	6·58	978858	·67	504854	7·25	495146	16
45	484107	6·57	978817	·67	505289	7·25	494711	15
46	484501	6·57	978777	·67	505724	7·24	494276	14
47	484895	6·56	978736	·67	506159	7·24	493841	13
48	485289	6·55	978696	·68	506593	7·23	493407	12
49	485682	6·55	978655	·68	507027	7·22	492973	11
50	486075	6·54	978615	·68	507460	7·22	492540	10
51	9·486467	6·53	9·978574	·68	9·507893	7·21	10·492107	9
52	486860	6·53	978533	·68	508326	7·21	491674	8
53	487251	6·52	978493	·68	508759	7·20	491241	7
54	487643	6·51	978452	·68	509191	7·19	490809	6
55	488034	6·51	978411	·68	509622	7·19	490378	5
56	488424	6·50	978370	·68	510054	7·18	489946	4
57	488814	6·50	978329	·68	510485	7·18	489515	3
58	489204	6·49	978288	·68	510916	7·17	489084	2
59	489593	6·48	978247	·68	511346	7·16	488654	1
60	489982	6·48	978206	·68	511776	7·16	488224	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

17 (72 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·489982	6·48	9·978206	·68	9·511776	7·16	10·488224	60
1	490371	6·48	978165	·68	512206	7·16	487794	59
2	490759	6·47	978124	·68	512635	7·15	487365	58
3	491147	6·46	978083	·69	513064	7·14	486936	57
4	491535	6·46	978042	·69	513493	7·14	486507	56
5	491922	6·45	978001	·69	513921	7·13	486079	55
6	492308	6·44	977959	·69	514349	7·13	485651	54
7	492695	6·44	977918	·69	514777	7·12	485223	53
8	493081	6·43	977877	·69	515204	7·12	484796	52
9	493466	6·42	977835	·69	515631	7·11	484369	51
10	493851	6·42	977794	·69	516057	7·10	483943	50
11	9·494236	6·41	9·977752	·69	9·516484	7·10	10·483516	49
12	494621	6·41	977711	·69	516910	7·09	483090	48
13	495005	6·40	977669	·69	517335	7·09	482665	47
14	495388	6·39	977628	·69	517761	7·08	482239	46
15	495772	6·39	977586	·69	518185	7·08	481815	45
16	496154	6·38	977544	·70	518610	7·07	481390	44
17	496537	6·37	977503	·70	519034	7·06	480966	43
18	496919	6·37	977461	·70	519458	7·06	480542	42
19	497301	6·36	977419	·70	519882	7·05	480118	41
20	497682	6·36	977377	·70	520305	7·05	479695	40
21	9·498064	6·35	9·977335	·70	9·520728	7·04	10·479272	39
22	498444	6·34	977293	·70	521151	7·03	478849	38
23	498825	6·34	977251	·70	521573	7·03	478427	37
24	499204	6·33	977209	·70	521995	7·03	478005	36
25	499584	6·32	977167	·70	522417	7·02	477583	35
26	499963	6·32	977125	·70	522838	7·02	477162	34
27	500342	6·31	977083	·70	523259	7·01	476741	33
28	500721	6·31	977041	·70	523680	7·01	476320	32
29	501099	6·30	976999	·70	524100	7·00	475900	31
30	501476	6·29	976957	·70	524520	6·99	475480	30
31	9·501854	6·29	9·976914	·70	9·524939	6·99	10·475061	29
32	502231	6·28	976872	·71	525359	6·98	474641	28
33	502607	6·28	976830	·71	525778	6·98	474222	27
34	502984	6·27	976787	·71	526197	6·97	473803	26
35	503360	6·26	976745	·71	526615	6·97	473385	25
36	503735	6·26	976702	·71	527033	6·96	472967	24
37	504110	6·25	976660	·71	527451	6·96	472549	23
38	504485	6·25	976617	·71	527868	6·95	472132	22
39	504860	6·24	976574	·71	528285	6·95	471715	21
40	505234	6·23	976532	·71	528702	6·94	471298	20
41	9·505608	6·23	9·976489	·71	9·529119	6·93	10·470881	19
42	505981	6·22	976446	·71	529535	6·93	470465	18
43	506354	6·22	976404	·71	529950	6·93	470050	17
44	506727	6·21	976361	·71	530366	6·92	469634	16
45	507099	6·20	676318	·71	530781	6·91	469219	15
46	507471	6·20	976275	·71	531196	6·91	468804	14
47	507843	6·19	976232	·72	531611	6·90	468389	13
48	508214	6·19	976189	·72	532025	6·90	467975	12
49	508585	6·18	976146	·72	532439	6·89	467561	11
50	508956	6·18	976103	·72	532853	6·89	467147	10
51	9·509326	6·17	9·976060	·72	9·533266	6·88	10·466734	9
52	509696	6·16	976017	·72	533679	6·88	466321	8
53	510065	6·16	975974	·72	534092	6·87	465908	7
54	510434	6·15	975930	·72	534504	6·87	465496	6
55	510803	6·15	975887	·72	534916	6·86	465084	5
56	511172	6·14	975844	·72	535328	6·86	464672	4
57	511540	6·13	975800	·72	535739	6·85	464261	3
58	511907	6·13	975757	·72	536150	6·85	463850	2
59	512275	6·12	975714	·72	536561	6·84	463439	1
60	512642	6·12	975670	·72	536972	6·84	463028	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(71 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·512642	6·12	9·975670	·73	9·536972	6·84	10·463028	60
1	513009	6·11	975627	·73	537382	6·83	462618	59
2	513375	6·11	975583	·73	537792	6·83	462208	58
3	513741	6·10	975539	·73	538202	6·82	461798	57
4	514107	6·09	975496	·73	538611	6·82	461389	56
5	514472	6·09	975452	·73	539020	6·81	460980	55
6	514837	6·08	975408	·73	539429	6·81	460571	54
7	515202	6·08	975365	·73	539837	6·80	460163	53
8	515566	6·07	975321	·73	540245	6·80	459755	52
9	515930	6·07	975277	·73	540653	6·79	459347	51
10	516294	6·06	975233	·73	541061	6·79	458939	50
11	9·516657	6·05	9·975189	·73	9·541468	6·78	10·458532	49
12	517020	6·05	975145	·73	541875	6·78	458125	48
13	517382	6·04	975101	·73	542281	6·77	457719	47
14	517745	6·04	975057	·73	542688	6·77	457312	46
15	518107	6·03	975013	·73	543094	6·76	456906	45
16	518468	6·03	974969	·74	543499	6·76	456501	44
17	518829	6·02	974925	·74	543905	6·75	456095	43
18	519190	6·01	974880	·74	544310	6·75	455690	42
19	519551	6·01	974836	·74	544715	6·74	455285	41
20	519911	6·00	974792	·74	545119	6·74	454881	40
21	9·520271	6·00	9·974748	·74	9·545524	6·73	10·454476	39
22	520631	5·99	974703	·74	545928	6·73	454072	38
23	520990	5·99	974659	·74	546331	6·72	453669	37
24	521349	5·98	974614	·74	546735	6·72	453265	36
25	521707	5·98	974570	·74	547138	6·71	452862	35
26	522066	5·97	974525	·74	547540	6·71	452460	34
27	522424	5·96	974481	·74	547943	6·70	452057	33
28	522781	5·96	974436	·74	548345	6·70	451655	32
29	523138	5·95	974391	·74	548747	6·69	451253	31
30	523495	5·95	974347	·75	549149	6·69	450851	30
31	9·523852	5·94	9·974302	·75	9·549550	6·68	10·450450	29
32	524208	5·94	974257	·75	549951	6·68	450049	28
33	524564	5·93	974212	·75	550352	6·67	449648	27
34	524920	5·93	974167	·75	550752	6·67	449248	26
35	525275	5·92	974122	·75	551152	6·66	448848	25
36	525630	5·91	974077	·75	551552	6·66	448448	24
37	525984	5·91	974032	·75	551952	6·65	448048	23
38	526339	5·90	973987	·75	552351	6·65	447649	22
39	526693	5·90	973942	·75	552750	6·65	447250	21
40	527046	5·89	973897	·75	553149	6·64	446851	20
41	9·527400	5·89	9·973852	·75	9·553548	6·64	10·446452	19
42	527753	5·88	973807	·75	553946	6·63	446054	18
43	528105	5·88	973761	·75	554344	6·63	445656	17
44	528458	5·87	973716	·76	554741	6·62	445259	16
45	528810	5·87	973671	·76	555139	6·62	444861	15
46	529161	5·86	973625	·76	555536	6·61	444464	14
47	529513	5·86	973580	·76	555933	6·61	444067	13
48	529864	5·85	973535	·76	556329	6·60	443671	12
49	530215	5·85	973489	·76	556725	6·60	443275	11
50	530565	5·84	973444	·76	557121	6·59	442879	10
51	9·530915	5·84	9·973398	·76	9·557517	6·59	10·442483	9
52	531265	5·83	973352	·76	557913	6·59	442087	8
53	531614	5·82	973307	·76	558308	6·58	441692	7
54	531963	5·82	973261	·76	558702	6·58	441298	6
55	532312	5·81	973215	·76	559097	6·57	440903	5
56	532661	5·81	973169	·76	559491	6·57	440509	4
57	533009	5·80	973124	·76	559885	6·56	440115	3
58	533357	5·80	973078	·76	560279	6·56	439721	2
59	533704	5·79	973032	·77	560673	6·55	439327	1
60	534052	5·78	972986	·77	561066	6·55	438934	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·534052	5·78	9·972986	·77	9·561066	6·55	10·438934	60
1	534399	5·77	972940	·77	561459	6·54	438541	59
2	534745	5·77	972894	·77	561851	6·54	438149	58
3	535092	5·77	972848	·77	562244	6·53	437756	57
4	535438	5·76	972802	·77	562636	6·53	437364	56
5	535783	5·76	972755	·77	563028	6·53	436972	55
6	536129	5·75	972709	·77	563419	6·52	436581	54
7	536474	5·74	972663	·77	563811	6·52	436189	53
8	536818	5·74	972617	·77	564202	6·51	435798	52
9	537163	5·73	972570	·77	564592	6·51	435408	51
10	537507	5·73	972524	·77	564983	6·50	435017	50
11	9·537851	5·72	9·972478	·77	9·565373	6·50	10·434627	49
12	538194	5·72	972431	·78	565763	6·49	434237	48
13	538538	5·71	972385	·78	566153	6·49	433847	47
14	538880	5·71	972338	·78	566542	6·49	433458	46
15	539223	5·70	972291	·78	566932	6·48	433068	45
16	539565	5·70	972245	·78	567320	6·48	432680	44
17	539907	5·69	972198	·78	567709	6·47	432291	43
18	540249	5·69	972151	·78	568098	6·47	431902	42
19	540590	5·68	972105	·78	568486	6·46	431514	41
20	540931	5·68	972058	·78	568873	6·46	431127	40
21	9·541272	5·67	9·972011	·78	9·569261	6·45	10·430739	39
22	541613	5·67	971964	·78	569648	6·45	430352	38
23	541953	5·66	971917	·78	570035	6·45	429965	37
24	542293	5·66	971870	·78	570422	6·44	429578	36
25	542632	5·65	971823	·78	570809	6·44	429191	35
26	542971	5·65	971776	·78	571195	6·43	428805	34
27	543310	5·64	971729	·79	571581	6·43	428419	33
28	543649	5·64	971682	·79	571967	6·42	428033	32
29	543987	5·63	971635	·79	572352	6·42	427648	31
30	544325	5·63	971588	·79	572738	6·42	427262	30
31	9·544663	5·62	9·971540	·79	9·573123	6·41	10·426877	29
32	545000	5·62	971493	·79	573507	6·41	426493	28
33	545338	5·61	971446	·79	573892	6·40	426108	27
34	545674	5·61	971398	·79	574276	6·40	425724	26
35	546011	5·60	971351	·79	574660	6·39	425340	25
36	546347	5·60	971303	·79	575044	6·39	424956	24
37	546683	5·59	971256	·79	575427	6·39	424573	23
38	547019	5·59	971208	·79	575810	6·38	424190	22
39	547354	5·58	971161	·79	576193	6·38	423807	21
40	547689	5·58	971113	·79	576576	6·37	423424	20
41	9·548024	5·57	9·971066	·80	9·576958	6·37	10·423041	10
42	548359	5·57	971018	·80	577341	6·36	422659	18
43	548693	5·56	970970	·80	577723	6·36	422277	17
44	549027	5·56	970922	·80	578104	6·36	421896	16
45	549360	5·55	970874	·80	578486	6·35	421514	15
46	549693	5·55	970827	·80	578867	6·35	421133	14
47	550026	5·54	970779	·80	579248	6·34	420752	13
48	550359	5·54	970731	·80	579629	6·34	420371	12
49	550692	5·53	970683	·80	580009	6·34	419991	11
50	551024	5·53	970635	·80	580389	6·33	419611	10
51	9·551356	5·52	9·970586	·80	9·580769	6·33	10·419231	9
52	551687	5·52	970538	·80	581149	6·32	418851	8
53	552018	5·52	970490	·80	581528	6·32	418472	7
54	552349	5·51	970442	·80	581907	6·32	418093	6
55	552680	5·51	970394	·80	582286	6·31	417714	5
56	553010	5·50	970345	·81	582665	6·31	417335	4
57	553341	5·50	970297	·81	583043	6·30	416957	3
58	553670	5·49	970249	·81	583422	6·30	416578	2
59	554000	5·49	970200	·81	583800	6·29	416200	1
60	554329	5·48	970152	·81	584177	6·29	415823	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(69 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·554329	5·48	9·970152	·81	9·584177	6·29	10·415823	60
1	554658	5·48	970103	·81	584555	6·29	415445	59
2	554987	5·47	970055	·81	584932	6·28	415068	58
3	555315	5·47	970006	·81	585309	6·28	414691	57
4	555643	5·46	969957	·81	585686	6·27	414314	56
5	555971	5·46	969909	·81	586062	6·27	413938	55
6	556299	5·45	969860	·81	586439	6·27	413561	54
7	556626	5·45	969811	·81	586815	6·26	413185	53
8	556953	5·44	969762	·81	587190	6·26	412810	52
9	557280	5·44	969714	·81	587566	6·25	412434	51
10	557606	5·43	969665	·81	587941	6·25	412059	50
11	9·557932	5·43	9·969616	·82	9·588316	6·25	10·411684	49
12	558258	5·43	969567	·82	588691	6·24	411309	48
13	558583	5·42	969518	·82	589066	6·24	410934	47
14	558909	5·42	969469	·82	589440	6·23	410560	46
15	559234	5·41	969420	·82	589814	6·23	410186	45
16	559558	5·41	969370	·82	590188	6·23	409812	44
17	559883	5·40	969321	·82	590562	6·22	409438	43
18	560207	5·40	969272	·82	590935	6·22	409065	42
19	560531	5·39	969223	·82	591308	6·22	408692	41
20	560855	5·39	969173	·82	591681	6·21	408319	40
21	9·561178	5·38	9·969124	·82	9·592054	6·21	10·407946	39
22	561501	5·38	969075	·82	592426	6·20	407574	38
23	561824	5·37	969025	·82	592798	6·20	407202	37
24	562146	5·37	968976	·82	593170	6·19	406829	36
25	562468	5·36	968926	·83	593542	6·19	406458	35
26	562790	5·36	968877	·83	593914	6·18	406086	34
27	563112	5·36	968827	·83	594285	6·18	405715	33
28	563433	5·35	968777	·83	594656	6·18	405344	32
29	563755	5·35	968728	·83	595027	6·17	404973	31
30	564075	5·34	968678	·83	595398	6·17	404602	30
31	9·564396	5·34	9·968628	·83	9·595768	6·17	10·404232	29
32	564716	5·33	968578	·83	596138	6·16	403862	28
33	565036	5·33	968528	·83	596508	6·16	403492	27
34	565356	5·32	968479	·83	596878	6·16	403122	26
35	565676	5·32	968429	·83	597247	6·15	402753	25
36	565995	5·31	968379	·83	597616	6·15	402384	24
37	566314	5·31	968329	·83	597985	6·15	402015	23
38	566632	5·31	968278	·83	598354	6·14	401646	22
39	566951	5·30	968228	·84	598722	6·14	401278	21
40	567269	5·30	968178	·84	599091	6·13	400909	20
41	9·567587	5·29	9·968128	·84	9·599459	6·13	10·400541	19
42	567904	5·29	968078	·84	599827	6·13	400173	18
43	568222	5·28	968027	·84	600194	6·12	399806	17
44	568539	5·28	967977	·84	600562	6·12	399438	16
45	568856	5·28	967927	·84	600929	6·11	399071	15
46	569172	5·27	967876	·84	601296	6·11	398704	14
47	569488	5·27	967826	·84	601662	6·11	398338	13
48	569804	5·26	967775	·84	602029	6·10	397971	12
49	570120	5·26	967725	·84	602395	6·10	397605	11
50	570435	5·25	967674	·84	602761	6·10	397239	10
51	9·570751	5·25	9·967624	·84	9·603127	6·09	10·396873	9
52	571066	5·24	967573	·84	603493	6·09	396507	8
53	571380	5·24	967522	·85	603858	6·09	396142	7
54	571695	5·23	967471	·85	604223	6·08	395777	6
55	572009	5·23	967421	·85	604588	6·08	395412	5
56	572323	5·23	967370	·85	604953	6·07	395047	4
57	572636	5·22	967319	·85	605317	6·07	394683	3
58	572950	5·22	967268	·85	605682	6·07	394318	2
59	573263	5·21	967217	·85	606046	6·06	393954	1
60	573575	5·21	967166	·85	606410	6·06	393590	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(68 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·573575	5·21	9·967166	·85	9·606410	6·06	10·393590	60
1	573888	5·20	967115	·85	606773	6·06	393227	59
2	574200	5·20	967064	·85	507137	6·05	392863	58
3	574512	5·19	967013	·85	607500	6·05	392500	57
4	574824	5·19	966961	·85	607863	6·04	392137	56
5	575136	5·19	966910	·85	608225	6·04	391775	55
6	575447	5·18	966859	·85	608588	6·04	391412	54
7	575758	5·18	966808	·85	608950	6·03	391050	53
8	576069	5·17	966756	·86	609312	5·03	390688	52
9	576379	5·17	966705	·86	609674	6 03	300326	51
10	576689	5·16	966653	·86	610036	6·02	389964	50
11	9·576999	5·16	9·966602	·86	9·610397	6·02	10 389603	49
12	577309	5·16	966550	·86	610759	6·02	389241	48
13	577618	5·15	966499	·86	611120	6·01	388880	47
14	577927	5·15	966447	·86	611480	6·01	388520	46
15	578236	5·14	966395	·86	611841	6·01	388159	45
16	578545	5·14	966344	·86	612201	6·00	387799	44
17	578853	5·13	966292	·86	612561	6·00	387439	43
18	579162	5·13	966240	·86	612921	6·00	387079	42
19	579470	5·13	966188	·86	613281	5·99	386719	41
20	579777	5·12	966136	·86	613641	5·99	386359	40
21	9·580085	5·12	9·966085	·87	9·614000	5·98	10·386000	39
22	580392	5·11	966033	·87	614359	5·98	385641	38
23	580699	5·11	965981	·87	614718	5·98	385282	37
24	581005	5·11	965928	·87	615077	5·97	384923	36
25	581312	5·10	965876	·87	615435	5·97	384565	35
26	581618	5·10	965824	·87	615793	5·97	384207	34
27	581924	5·09	965772	·87	616151	5·96	383849	33
28	582229	5·09	965720	·87	616509	5·96	383491	32
29	582535	5·09	965668	·87	616867	5·96	383133	31
30	582840	5·08	965615	·87	617224	5·95	382776	30
31	9·583145	5·08	9·965563	·87	9·617582	5·95	10·382418	29
32	583449	5·07	965511	·87	617939	5·95	382061	28
33	583754	5·07	965458	·87	618295	5·94	381705	27
34	584058	5·06	965406	·87	618652	5·94	381348	26
35	584361	5·06	965353	·88	619008	5·94	380992	25
36	584665	5·06	965301	·88	619364	5·93	380636	24
37	584968	5·05	965248	·88	619721	5·93	380279	23
38	585272	5·05	965195	·88	620076	5·93	379924	22
39	585574	5·04	965143	·88	620432	5·92	379568	21
40	585877	5·04	965090	·88	620787	5·92	379213	20
41	9·586179	5·03	9·965037	·88	9·621142	5·92	10·378858	19
42	586482	5·03	964984	·88	621497	5·91	378503	18
43	586783	5·03	964931	·88	621852	5·91	378148	17
44	587085	5·02	964879	·88	622207	5·90	377793	16
45	587386	5·02	964826	·88	622561	5·90	377439	15
46	587688	5·01	964773	·88	622915	5·90	377085	14
47	587989	5·01	964719	·88	623269	5·89	376731	13
48	588289	5·01	964666	·89	623623	5·89	376377	12
49	588590	5·00	964613	·89	623976	5·89	376024	11
50	588890	5·00	964560	·89	624330	5·88	375670	10
51	9·589190	4·99	9·964507	·89	9·624683	5·88	10·375317	9
52	589489	4·99	964454	·89	625036	5·88	374964	8
53	589789	4·99	964400	·89	625388	5·87	374612	7
54	590088	4·98	964347	·89	625741	5·87	374259	6
55	590387	4·98	964294	·89	626093	5·87	373907	5
56	590686	4·97	964240	·89	626445	5·86	373555	4
57	590984	4·97	964187	·89	626797	5·86	373203	3
58	591282	4·97	964133	·89	627149	5·86	372851	2
59	591580	4·96	964080	·89	627501	5·85	372499	1
60	591878	4·96	964026	·89	627852	5·85	372148	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(67 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·591878	4·96	9·964026	·89	9·627852	5·85	10·372148	60
1	592176	4·95	963972	·89	628203	5·85	371797	59
2	592473	4·95	963919	·89	628554	5·85	371446	58
3	592770	4·95	963865	·90	628905	5·84	371095	57
4	593067	4·94	963811	·90	629255	5·84	370745	56
5	593363	4·94	963757	·90	629606	5·83	370394	55
6	593659	4·93	963704	·90	629956	5·83	370044	54
7	593955	4·93	963650	·90	630306	5·83	369694	53
8	594251	4·93	963596	·90	630656	5·83	369344	52
9	594547	4·92	963542	·90	631005	5·82	368995	51
10	594842	4·92	963488	·90	631355	5·82	368645	50
11	9·595137	4·91	9·963434	·90	9·631704	5·82	10·368296	49
12	595432	4·91	963379	·90	632053	5·81	367947	48
13	595727	4·91	963325	·90	632401	5·81	367599	47
14	596021	4·90	963271	·90	632750	5·81	367250	46
15	596315	4·90	963217	·90	633098	5·80	366902	45
16	596609	4·89	963163	·90	633447	5·80	366553	44
17	596903	4·89	963108	·91	633795	5·80	366205	43
18	597196	4·89	963054	·91	634143	5·79	365857	42
19	597490	4·88	962999	·91	634490	5·79	365510	41
20	597783	4·88	962945	·91	634838	5·79	365162	40
21	9·598075	4·87	9·962890	·91	9·635185	5·78	10·364815	39
22	598368	4·87	962836	·91	635532	5·78	364468	38
23	598660	4·87	962781	·91	635879	5·78	364121	37
24	598952	4·86	962727	·91	636226	5·77	363774	36
25	599244	4·86	962672	·91	636572	5·77	363428	35
26	599536	4·85	962617	·91	636919	5·77	363081	34
27	599827	4·85	962562	·91	637265	5·77	362735	33
28	600118	4·85	962505	·91	637611	5·76	362389	32
29	600409	4·84	962453	·91	637956	5·76	362044	31
30	600700	4·84	962398	·92	638302	5·76	361698	30
31	9·600990	4·84	9·962343	·92	9·638647	5·75	10·361353	29
32	601280	4·83	962288	·92	638992	5·75	361008	28
33	601570	4·83	962233	·92	639337	5·75	360663	27
34	601860	4·82	962178	·92	639682	5·74	360318	26
35	602150	4·82	962123	·92	640027	5·74	359973	25
36	602439	4·82	962067	·92	640371	5·74	359629	24
37	602728	4·81	962012	·92	640716	5·73	359284	23
38	603017	4·81	961957	·92	641060	5·73	358940	22
39	603305	4·81	961902	·92	641404	5·73	358596	21
40	603594	4·80	961846	·92	641747	5·72	358253	20
41	9·603882	4·80	9·961791	·92	9·642091	5·72	10·357909	19
42	604170	4·79	961735	·92	642434	5·72	357566	18
43	604457	4·79	961680	·92	642777	5·72	357223	17
44	604745	4·79	961624	·93	643120	5·71	356880	16
45	605032	4·78	961569	·93	643463	5·71	356537	15
46	605319	4·78	961513	·93	643806	5·71	356194	14
47	605606	4·78	961458	·93	644148	5·70	355852	13
48	605892	4·77	961402	·93	644490	5·70	355510	12
49	606179	4·77	961346	·93	644832	5·70	355168	11
50	606465	4·76	961290	·93	645174	5·69	354826	10
51	9·606751	4·76	9·961235	·93	9·645516	5·69	10·354484	9
52	607036	4·76	961179	·93	645857	5·69	354143	8
53	607322	4·75	961123	·93	646199	5·69	353801	7
54	607607	4·75	961067	·93	646540	5·68	353460	6
55	607892	4·74	961011	·93	646881	5·68	353119	5
56	608177	4·74	960955	·93	647222	5·68	352778	4
57	608461	4·74	960899	·93	647562	5·67	352438	3
58	608745	4·73	960843	·94	647903	5·67	352097	2
59	609029	4·73	960786	·94	648243	5·67	351757	1
60	609313	4·73	960730	·94	648583	5·66	351417	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(66 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·609313	4·73	9·960730	·94	9·648583	5·66	10·351417	60
1	609597	4·72	960674	·94	648923	5·66	351077	59
2	609880	4·72	960618	·94	649263	5·66	350737	58
3	610164	4·72	960561	·94	649602	5·66	350398	57
4	610447	4·71	960505	·94	649942	5·65	350058	56
5	610729	4·71	960448	·94	650281	5·65	349719	55
6	611012	4·70	960392	·94	650620	5·65	349380	54
7	611294	4·70	960335	·94	650959	5·64	349041	53
8	611576	4·70	960279	·94	651297	5·64	348703	52
9	611858	4·69	960222	·94	651636	5·64	348364	51
10	612140	4·69	960165	·94	651974	5·63	348026	50
11	9·612421	4·69	9·960109	·95	9·652312	5·63	10·347688	49
12	612702	4·68	960052	·95	652650	5·63	347350	48
13	612983	4·68	959995	·95	652988	5·63	347012	47
14	613264	4·67	959938	·95	653326	5·62	346674	46
15	613545	4·67	959882	·95	653663	5·62	346337	45
16	613825	4·67	959825	·95	654000	5·62	346000	44
17	614105	4·66	959768	·95	654337	5·61	345663	43
18	614385	4·66	959711	·95	654674	5·61	345326	42
19	614665	4·66	959654	·95	655011	5·61	344989	41
20	614944	4·65	959596	·95	655348	5·61	344652	40
21	9·615223	4·65	9·959539	·95	9·655684	5·60	10·344316	39
22	615502	4·65	959482	·95	656020	5·60	343980	38
23	615781	4·64	959425	·95	656356	5·60	343644	37
24	616060	4·64	959368	·95	656692	5·59	343308	36
25	616338	4·64	959310	·96	657028	5·59	342972	35
26	616616	4·63	959253	·96	657364	5·59	342636	34
27	616894	4·63	959195	·96	657699	5·59	342301	33
28	617172	4·62	959138	·96	658034	5·58	341966	32
29	617450	4·62	959081	·96	658369	5·58	341631	31
30	617727	4·62	959023	·96	658704	5·58	341296	30
31	9·618004	4·61	9·958965	·96	9·659039	5·58	10·340961	29
32	618281	4·61	958908	·96	659373	5·57	340627	28
33	618558	4·61	958850	·96	659708	5·57	340292	27
34	618834	4·60	958792	·96	660042	5·57	339958	26
35	619110	4·60	958734	·96	660376	5·57	339624	25
36	619386	4·60	958677	·96	660710	5·56	339290	24
37	619662	4·59	958619	·96	661043	5·56	338957	23
38	619938	4·59	958561	·96	661377	5·56	338623	22
39	620213	4·59	958503	·97	661710	5·55	338290	21
40	620488	4·58	958445	·97	662043	5·55	337957	20
41	9·620763	4·58	9·958387	·97	9·662376	5·55	10·337624	19
42	621038	4·57	958329	·97	662709	5·54	337291	18
43	621313	4·57	958271	·97	663042	5·54	336958	17
44	621587	4·57	958213	·97	663375	5·54	336625	16
45	621861	4·56	958154	·97	663707	5·54	336293	15
46	622135	4·56	958096	·97	664039	5·53	335961	14
47	622409	4·56	958038	·97	664371	5·53	335629	13
48	622682	4·55	957979	·97	664703	5·53	335297	12
49	622956	4·55	957921	·97	665035	5·53	334965	11
50	623229	4·55	957863	·97	665366	5·52	334634	10
51	9·623502	4·54	9·957804	·97	9·665697	5·52	10·334303	9
52	623774	4·54	957746	·98	666029	5·52	333971	8
53	624047	4·54	957687	·98	666360	5·51	333640	7
54	624319	4·53	957628	·98	666691	5·51	333309	6
55	624591	4·53	957570	·98	667021	5·51	332979	5
56	624863	4·53	957511	·98	667352	5·51	332648	4
57	625135	4·52	957452	·98	667682	5·50	332318	3
58	625406	4·52	957393	·98	668013	5·50	331987	2
59	625677	4·52	957335	·98	668343	5·50	331657	1
60	625948	4·51	957276	·98	668672	5·50	331328	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(65 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·625948	4·51	9·957276	·98	9·668673	5·50	10·331327	60
1	626219	4·51	957217	·98	669002	5·49	330998	59
2	626490	4·51	957158	·98	669332	5·49	330668	58
3	626760	4·50	957099	·98	669661	5·49	330339	57
4	627030	4·50	957040	·98	669991	5·48	330009	56
5	627300	4·50	956981	·98	670320	5·48	329680	55
6	627570	4·49	956921	·99	670649	5·48	329351	54
7	627840	4·49	956862	·99	670977	5·48	329023	53
8	628109	4·49	956803	·99	671306	5·47	328694	52
9	628378	4·48	956744	·99	671634	5·47	328366	51
10	628647	4·48	956684	·99	671963	5·47	328037	50
11	9·628916	4·47	9·956625	·99	9·672291	5·47	10·327709	49
12	629185	4·47	956566	·99	672619	5·46	327381	48
13	629453	4·47	956506	·99	672947	5·46	327053	47
14	629721	4·46	956447	·99	673274	5·46	326726	46
15	629989	4·46	956387	·99	673602	5·46	326398	45
16	630257	4·46	956327	·99	673929	5·45	326071	44
17	630524	4·46	956268	·99	674257	5·45	325743	43
18	630792	4·45	956208	1·00	674584	5·45	325416	42
19	631059	4·45	956148	1·00	674910	5·44	325090	41
20	631326	4·45	956089	1·00	675237	5·44	324763	40
21	9·631593	4·44	9·956029	1·00	9·675564	5·44	10·324436	39
22	631859	4·44	955969	1·00	675890	5·44	324110	38
23	632125	4·44	955909	1·00	676216	5·43	323784	37
24	632392	4·43	955849	1·00	676543	5·43	323457	36
25	632658	4·43	955789	1·00	676869	5·43	323131	35
26	632923	4·43	955729	1·00	677194	5·43	322806	34
27	633189	4·42	955669	1·00	677520	5·42	322480	33
28	633454	4·42	955609	1·00	677846	5·42	322154	32
29	633719	4·42	955548	1·00	678171	5·42	321829	31
30	633984	4·41	955488	1·00	678496	5·42	321504	30
31	9·634249	4·41	9·955428	1·01	9·678821	5·41	10·321179	29
32	634514	4·40	955368	1·01	679146	5·41	320854	28
33	634778	4·40	955307	1·01	679471	5·41	320529	27
34	635042	4·40	955247	1·01	679795	5·41	320205	26
35	635306	4·39	955186	1·01	680120	5·40	319880	25
36	635570	4·39	955126	1·01	680444	5·40	319556	24
37	635834	4·39	955065	1·01	680768	5·40	319232	23
38	636097	4·38	955005	1·01	681092	5·40	318908	22
39	636360	4·38	954944	1·01	681416	5·39	318584	21
40	636623	4·38	954883	1·01	681740	5·39	318260	20
41	9·636886	4·37	9·954823	1·01	9·682063	5·39	10·317937	19
42	637148	4·37	954762	1·01	682387	5·39	317613	18
43	637411	4·37	954701	1·01	682710	5·38	317290	17
44	637673	4·37	954640	1·01	683033	5·38	316967	16
45	637935	4·36	954579	1·01	683356	5·38	316644	15
46	638197	4·36	954518	1·02	683679	5·38	316321	14
47	638458	4·36	954457	1·02	684001	5·37	315999	13
48	638720	4·35	954396	1·02	684324	5·37	315676	12
49	638981	4·35	954335	1·02	684646	5·37	315354	11
50	639242	4·35	954274	1·02	684968	5·37	315032	10
51	9·639503	4·34	9·954213	1·02	9·685290	5·36	10·314710	9
52	639764	4·34	954152	1·02	685612	5·36	314388	8
53	640024	4·34	954090	1·02	685934	5·36	314066	7
54	640284	4·33	954029	1·02	686255	5·36	313745	6
55	640544	4·33	953968	1·02	686577	5·35	313423	5
56	640804	4·33	953906	1·02	686898	5·35	313102	4
57	641064	4·32	953845	1·02	687219	5·35	312781	3
58	641324	4·32	953783	1·02	687540	5·35	312460	2
59	641584	4·32	953722	1·03	687861	5·34	312139	1
60	641842	4·31	953660	1·03	688182	5·34	311818	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(64 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·641842	4·31	9·953660	1·03	9·688182	5·34	10·311818	60
1	642101	4·31	953599	1·03	688502	5·34	311498	59
2	642360	4·31	953537	1·03	688823	5·34	311177	58
3	642618	4·30	953475	1·03	689143	5·33	310857	57
4	642877	4·30	953413	1·03	689463	5·33	310537	56
5	643135	4·30	953352	1·03	689783	5·33	310217	55
6	643393	4·30	953290	1·03	690103	5·33	309897	54
7	643650	4·29	953228	1·03	690423	5·33	309577	53
8	643908	4·29	953166	1·03	690742	5·32	309258	52
9	644165	4·29	953104	1·03	691062	5·32	308938	51
10	644423	4·28	953042	1·03	691381	5·32	308619	50
11	9·644680	4·28	9·952980	1·04	9·691700	5·31	10·308300	49
12	644936	4·28	952918	1·04	692019	5·31	307981	48
13	645103	4·27	952855	1·04	692338	5·31	307662	47
14	645450	4·27	952793	1·04	692656	5·31	307344	46
15	645706	4·27	952731	1·04	692975	5·31	307025	45
16	645962	4·26	952669	1·04	693293	5·30	306707	44
17	646218	4·26	952606	1·04	693612	5·30	306388	43
18	646474	4·26	952544	1·04	693930	5·30	306070	42
19	646729	4·25	952481	1·04	694248	5·30	305752	41
20	646984	4·25	952419	1·04	694566	5·29	305434	40
21	9·647240	4·25	9·952356	1·04	9·694883	5·29	10·305117	39
22	647494	4·24	952294	1·04	695201	5·29	304799	38
23	647749	4·24	952231	1·04	695518	5·29	304482	37
24	648004	4·24	952168	1·05	695836	5·29	304164	36
25	648258	4·24	952106	1·05	696153	5·28	303847	35
26	648512	4·23	952043	1·05	696470	5·28	303530	34
27	648766	4·23	951980	1·05	696787	5·28	303213	33
28	649020	4·23	951917	1·05	697103	5·28	302897	32
29	649274	4·22	951854	1·05	697420	5·27	302580	31
30	649527	4·22	951791	1·05	697736	5·27	302264	30
31	9·649781	4·22	9·951728	1·05	9·698053	5·27	10·301947	29
32	650034	4·22	951665	1·05	698369	5·27	301631	28
33	650287	4·21	951602	1·05	698685	5·26	301315	27
34	650539	4·21	951539	1·05	699001	5·26	300999	26
35	650792	4·21	951476	1·05	699316	5·26	300684	25
36	651044	4·20	951412	1·05	699632	5·26	300368	24
37	651297	4·20	951349	1·06	699947	5·26	300053	23
38	651549	4·20	951286	1·06	700263	5·25	299737	22
39	651800	4·19	951222	1·06	700578	5·25	299422	21
40	652052	4·19	951159	1·06	700893	5·25	299107	20
41	9·652304	4·19	9·951096	1·06	9·701208	5·24	10·298792	19
42	652555	4·18	951032	1·06	701523	5·24	298477	18
43	652806	4·18	950968	1·06	701837	5·24	298163	17
44	653057	4·18	950905	1·06	702152	5·24	297848	16
45	653308	4·18	950841	1·06	702466	5·24	297534	15
46	653558	4·17	950778	1·06	702780	5·23	297220	14
47	653808	4·17	950714	1·06	703095	5·23	296905	13
48	654059	4·17	950650	1·06	703409	5·23	296591	12
49	654309	4·16	950586	1·06	703723	5·23	296277	11
50	654558	4·16	950522	1·07	704036	5·22	295964	10
51	9·654808	4·16	9·950458	1·07	9·704350	5·22	10·295650	9
52	655058	4·16	950394	1·07	704663	5·22	295337	8
53	655307	4·15	950330	1·07	704977	5·22	295023	7
54	655556	4·15	950266	1·07	705290	5·22	294710	6
55	655805	4·15	950202	1·07	705603	5·21	294397	5
56	656054	4·14	950138	1·07	705916	5·21	294084	4
57	656302	4·14	950074	1·07	706228	5·21	293772	3
58	656551	4·14	950010	1·07	706541	5·21	293459	2
59	656799	4·13	949945	1·07	706854	5·21	293146	1
60	657047	4·13	949881	1·07	707166	5·20	292834	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(63 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·657047	4·13	9·949881	1·07	9·707166	5·20	10·292834	60
1	657295	4·13	949816	1·07	707478	5·20	292522	59
2	657542	4·12	949752	1·07	707790	5·20	292210	58
3	657790	4·12	949688	1·08	708102	5·20	291898	57
4	658037	4·12	949623	1·08	708414	5·19	291586	56
5	658284	4·12	949558	1·08	708726	5·19	291274	55
6	658531	4·11	949494	1·08	709037	5·19	290963	54
7	658778	4·11	949429	1·08	709349	5·19	290651	53
8	659025	4·11	949364	1·08	709660	5·19	290340	52
9	659271	4·10	949300	1·08	709971	5·18	290029	51
10	659517	4·10	949235	1·08	710282	5·18	289718	50
11	9·659763	4·10	9·949170	1·08	9·710593	5·18	10·289407	49
12	660009	4·09	949105	1·08	710904	5·18	289096	48
13	660255	4·09	949040	1·08	711215	5·18	288785	47
14	660501	4·09	948975	1·08	711525	5·17	288475	46
15	660746	4·09	948910	1·08	711836	5·17	288164	45
16	660991	4·08	948845	1·08	712146	5·17	287854	44
17	661236	4·08	948780	1·09	712456	5·17	287544	43
18	661481	4·08	948715	1·09	712766	5·16	287234	42
19	661726	4·07	948650	1·09	713076	5·16	286924	41
20	661970	4·07	948584	1·09	713386	5·16	286614	40
21	9·662214	4·07	9·948519	1·09	9·713696	5·16	10·286304	39
22	662459	4·07	948454	1·09	714005	5·16	285995	38
23	662703	4·06	948388	1·09	714314	5·15	285686	37
24	662946	4·06	948323	1·09	714624	5·15	285376	36
25	663190	4·06	948257	1·09	714933	5·15	285067	35
26	663433	4·05	948192	1·09	715242	5·15	284758	34
27	663677	4·05	948126	1·09	715551	5·14	284449	33
28	663920	4·05	948060	1·09	715860	5·14	284140	32
29	664163	4·05	947995	1·10	716168	5·14	283832	31
30	664406	4·04	947929	1·10	716477	5·14	283523	30
31	9·664648	4·04	9·947863	1·10	9·716785	5·14	10·283215	29
32	664891	4·04	947797	1·10	717093	5·13	282907	28
33	665133	4·03	947731	1·10	717401	5·13	282599	27
34	665375	4·03	947665	1·10	717709	5·13	282291	26
35	665617	4·03	947600	1·10	718017	5·13	281983	25
36	665859	4·02	947533	1·10	718325	5·13	281670	24
37	666100	4·02	947467	1·10	718633	5·12	281367	23
38	666342	4·02	947401	1·10	718940	5·12	281060	22
39	666583	4·02	947335	1·10	719248	5·12	280752	21
40	666824	4·01	947269	1·10	719555	5·12	280445	20
41	9·667065	4·01	9·947203	1·10	9·719862	5·12	10·280138	19
42	667305	4·01	947136	1·11	720169	5·11	279831	18
43	667546	4·01	947070	1·11	720476	5·11	279524	17
44	667786	4·00	947004	1·11	720783	5·11	279217	16
45	668027	4·00	946937	1·11	721089	5·11	278911	15
46	668267	4·00	946871	1·11	721396	5·11	278604	14
47	668506	3·99	946804	1·11	721702	5·10	278298	13
48	668746	3·99	946738	1·11	722009	5·10	277991	12
49	668986	3·99	946671	1·11	722315	5·10	277685	11
50	669225	3·99	946604	1·11	722621	5·10	277379	10
51	9·669464	3·98	9·946538	1·11	9·722927	5·10	10·277073	9
52	669703	3·98	946471	1·11	723232	5·09	276768	8
53	669942	3·98	946404	1·11	723538	5·09	276462	7
54	670181	3·97	946337	1·11	723844	5·09	276156	6
55	670419	3·97	946270	1·12	724149	5·09	275851	5
56	670658	3·97	946203	1·12	724454	5·09	275546	4
57	670896	3·97	946136	1·12	724759	5·08	275241	3
58	671134	3·96	946069	1·12	725065	5·08	274935	2
59	671372	3·96	946002	1·12	725369	5·08	274631	1
60	671609	3·96	945935	1·12	725674	5·08	274326	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(62 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·671609	3·96	9·945935	1·12	9·725674	5·08	10·274326	60
1	671847	3·95	945868	1·12	725979	5·08	274021	59
2	672084	3·95	945800	1·12	726284	5·07	273716	58
3	672321	3·95	945733	1·12	726588	5·07	273412	57
4	672558	3·95	945666	1·12	726892	5·07	273108	56
5	672795	3·94	945598	1·12	727197	5·07	272803	55
6	673032	3·94	945531	1·12	727501	5·07	272499	54
7	673268	3·94	945464	1·13	727805	5·06	272195	53
8	673505	3·94	945396	1·13	728109	5·06	271891	52
9	673741	3·93	945328	1·13	728412	5·06	271588	51
10	673977	3·93	945261	1·13	728716	5·06	271284	50
11	9·674213	3·93	9·945193	1·13	9·729020	5·06	10·270980	49
12	674448	3·92	945125	1·13	729323	5·05	270677	48
13	674684	3·92	945058	1·13	729626	5·05	270374	47
14	674919	3·92	944990	1·13	729929	5·05	270071	46
15	675155	3·92	944922	1·13	730233	5·05	269767	45
16	675390	3·91	944854	1·13	730535	5·05	269465	44
17	675624	3·91	944786	1·13	730838	5·04	269162	43
18	675859	3·91	944718	1·13	731141	5·04	268859	42
19	676094	3·91	944650	1·13	731444	5·04	268556	41
20	676328	3·90	944582	1·14	731746	5·04	268254	40
21	9·676562	3·90	9·944514	1·14	9·732048	5·04	10·267952	39
22	676796	3·90	944446	1·14	732351	5·03	267649	38
23	677030	3·90	944377	1·14	732653	5·03	267347	37
24	677264	3·89	944309	1·14	732955	5·03	267045	36
25	677498	3·89	944241	1·14	733257	5·03	266743	35
26	677731	3·89	944172	1·14	733558	5·03	266442	34
27	677964	3·88	944104	1·14	733860	5·02	266140	33
28	678197	3·88	944036	1·14	734162	5·02	265838	32
29	678430	3·88	943967	1·14	734463	5·02	265537	31
30	678663	3·88	943899	1·14	734764	5·02	265236	30
31	9·678895	3·87	9·943830	1·14	9·735066	5·02	10·264934	29
32	679128	3·87	943761	1·14	735367	5·02	264633	28
33	679360	3·87	943693	1·15	735668	5·01	264332	27
34	679592	3·87	943624	1·15	735969	5·01	264031	26
35	679824	3·86	943555	1·15	736269	5·01	263731	25
36	680056	3·86	943486	1·15	736570	5·01	263430	24
37	680288	3·86	943417	1·15	736871	5·01	263129	23
38	680519	3·85	943348	1·15	737171	5·00	262829	22
39	680750	3·85	943279	1·15	737471	5·00	262529	21
40	680982	3·85	943210	1·15	737771	5·00	262229	20
41	9·681213	3·85	9·943141	1·15	9·738071	5·00	10·261929	19
42	681443	3·84	943072	1·15	738371	5·00	261629	18
43	681674	3·84	943003	1·15	738671	4·99	261329	17
44	681905	3·84	942934	1·15	738971	4·99	261029	16
45	682135	3·84	942864	1·15	739271	4·99	260729	15
46	682365	3·83	942795	1·16	739570	4·99	260430	14
47	682595	3·83	942726	1·16	739870	4·99	260130	13
48	682825	3·83	942656	1·16	740169	4·99	259831	12
49	683055	3·83	942587	1·16	740468	4·98	259532	11
50	683284	3·82	942517	1·16	740767	4·98	259233	10
51	9·683514	3·82	9·942448	1·16	9·741066	4·98	10·258934	9
52	683743	3·82	942378	1·16	741365	4·98	258635	8
53	683972	3·82	942308	1·16	741664	4·98	258336	7
54	684201	3·81	942239	1·16	741962	4·97	258038	6
55	684430	3·81	942169	1·16	742261	4·97	257739	5
56	684658	3·81	942099	1·16	742559	4·97	257441	4
57	684887	3·80	942029	1·16	742858	4·97	257142	3
58	685115	3·80	941959	1·16	743156	4·97	256844	2
59	685343	3·80	941889	1·17	743454	4·97	256546	1
60	685571	3·80	941819	1·17	743752	4·96	256248	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·685571	3·80	9·941819	1·17	9·743752	4·96	10·256248	60
1	685799	3·79	941749	1·17	744050	4·96	255950	59
2	686027	3·79	941679	1·17	744348	4·96	255652	58
3	686254	3·79	941609	1·17	744645	4·96	255355	57
4	686482	3·79	941539	1·17	744943	4·96	255057	56
5	686709	3·78	941469	1·17	745240	4·96	254760	55
6	686936	3·78	941398	1·17	745538	4·95	254462	54
7	687163	3·78	941328	1·17	745835	4·95	254165	53
8	687389	3·78	941258	1·17	746132	4·95	253868	52
9	687616	3·77	941187	1·17	746429	4·95	253571	51
10	687843	3·77	941117	1·17	746726	4·95	253274	50
11	9·688069	3·77	9·941046	1·18	9·747023	4·94	10·252977	49
12	688295	3·77	940975	1·18	747319	4·94	252681	48
13	688521	3·76	940905	1·18	747616	4·94	252384	47
14	688747	3·76	940834	1·18	747913	4·94	252087	46
15	688972	3·76	940763	1·18	748209	4·94	251791	45
16	689198	3·76	940693	1·18	748505	4·93	251495	44
17	689423	3·75	940622	1·18	748801	4·93	251199	43
18	689648	3·75	940551	1·18	749097	4·93	250903	42
19	689873	3·75	940480	1·18	749393	4·93	250607	41
20	690098	3·75	940409	1·18	749689	4·93	250311	40
21	9·690323	3·74	9·940338	1·18	9·749985	4·93	10·250015	39
22	690548	3·74	940267	1·18	750281	4·92	249719	38
23	690772	3·74	940196	1·18	750576	4·92	249424	37
24	690996	3·74	940125	1·19	750872	4·92	249128	36
25	691220	3·73	940054	1·19	751167	4·92	248833	35
26	691444	3·73	939982	1·19	751462	4·92	248538	34
27	691668	3·73	939911	1·19	751757	4·92	248243	33
28	691892	3·73	939840	1·19	752052	4·91	247948	32
29	692115	3·72	939768	1·19	752347	4·91	247653	31
30	692339	3·72	939697	1·19	752642	4·91	247358	30
31	9·692562	3·72	9·939625	1·19	9·752937	4·91	10·247063	29
32	692785	3·71	939554	1·19	753231	4·91	246769	28
33	693008	3·71	939482	1·19	753526	4·91	246474	27
34	693231	3·71	939410	1·19	753820	4·90	246180	26
35	693453	3·71	939339	1·19	754115	4·90	245885	25
36	693676	3·70	939267	1·20	754409	4·90	245591	24
37	693898	3·70	939195	1·20	754703	4·90	245297	23
38	694120	3·70	939123	1·20	754997	4·90	245003	22
39	694342	3·70	939052	1·20	755291	4·90	244709	21
40	694564	3·69	938980	1·20	755585	4·89	244415	20
41	9·694786	3·69	9·938908	1·20	9·755878	4·89	10·244122	19
42	695007	3·69	938836	1·20	756172	4·89	243828	18
43	695229	3·69	938763	1·20	756465	4·89	243535	17
44	695450	3·68	938691	1·20	756759	4·89	243241	16
45	695671	3·68	938619	1·20	757052	4·89	242948	15
46	695892	3·68	938547	1·20	757345	4·88	242655	14
47	696113	3·68	938475	1·20	757638	4·88	242362	13
48	696334	3·67	938402	1·21	757931	4·88	242069	12
49	696554	3·67	938330	1·21	758224	4·88	241776	11
50	696775	3·67	938258	1·21	758517	4·88	241483	10
51	9·696995	3·67	9·938185	1·21	9·758810	4·88	10·241190	9
52	697215	3·66	938113	1·21	759102	4·87	240898	8
53	697435	3·66	938040	1·21	759395	4·87	240605	7
54	697654	3·66	937967	1·21	759687	4·87	240313	6
55	697874	3·66	937895	1·21	759979	4·87	240021	5
56	698094	3·65	937822	1·21	760272	4·87	239728	4
57	698313	3·65	937749	1·21	760564	4·87	239436	3
58	698532	3·65	937676	1·21	760856	4·86	239144	2
59	698751	3·65	937604	1·21	761148	4·86	238852	1
60	698970	3·64	937531	1·21	761439	4·86	238561	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·698970	3·64	9·937531	1·21	9·761439	4·86	10·238561	60
1	699189	3·64	937458	1·22	761731	4·86	238269	59
2	699407	3·64	937385	1·22	762023	4·86	237977	58
3	699626	3·64	937312	1·22	762314	4·86	237686	57
4	699844	3·63	937238	1·22	762606	4·85	237394	56
5	700062	3·63	937165	1·22	762897	4·85	237103	55
6	700280	3·63	937092	1·22	763188	4·85	236812	54
7	700498	3·63	937019	1·22	763479	4·85	236521	53
8	700716	3·63	936946	1·22	763770	4·85	236230	52
9	700933	3·62	936872	1·22	764061	4·85	235939	51
10	701151	3·62	936799	1·22	764352	4·84	235648	50
11	9·701368	3·62	9·936725	1·22	9·764643	4·84	10·235357	49
12	701585	3·62	936652	1·23	764933	4·84	235067	48
13	701802	3·61	936578	1·23	765224	4·84	234776	47
14	702019	3·61	936505	1·23	765514	4·84	234486	46
15	702236	3·61	936431	1·23	765805	4·84	234195	45
16	702452	3·61	936357	1·23	766095	4·84	233905	44
17	702669	3·60	936284	1·23	766385	4·83	233615	43
18	702885	3·60	936210	1·23	766675	4·83	233325	42
19	703101	3·60	936136	1·23	766965	4·83	233035	41
20	703317	3·60	936062	1·23	767255	4·83	232745	40
21	9·703533	3·59	9·935988	1·23	9·767545	4·83	10·232455	39
22	703749	3·59	935914	1·23	767834	4·83	232166	38
23	703964	3·59	935840	1·23	768124	4·82	231876	37
24	704179	3·59	935766	1·24	768413	4·82	231587	36
25	704395	3·59	935692	1·24	768703	4·82	231297	35
26	704610	3·58	935618	1·24	768992	4·82	231008	34
27	704825	3·58	935543	1·24	769281	4·82	230719	33
28	705040	3·58	935469	1·24	769570	4·82	230430	32
29	705254	3·58	935395	1·24	769860	4·81	230140	31
30	705469	3·57	935320	1·24	770148	4·81	229852	30
31	9·705683	3·57	9·935246	1·24	9·770437	4·81	10·229563	29
32	705898	3·57	935171	1·24	770726	4·81	229274	28
33	706112	3·57	935097	1·24	771015	4·81	228985	27
34	706326	3·56	935022	1·24	771303	4·81	228697	26
35	706539	3·56	934948	1·24	771592	4·81	228408	25
36	706753	3·56	934873	1·24	771880	4·80	228120	24
37	706967	3·56	934798	1·25	772168	4·80	227832	23
38	707180	3·55	934723	1·25	772457	4·80	227543	22
39	707393	3·55	934649	1·25	772745	4·80	227255	21
40	707606	3·55	934574	1·25	773033	4·80	226967	20
41	9·707819	3·55	9·934499	1·25	9·773321	4·80	10·226679	19
42	708032	3·54	934424	1·25	773608	4·79	226392	18
43	708245	3·54	934349	1·25	773896	4·79	226104	17
44	708458	3·54	934274	1·25	774184	4·79	225816	16
45	708670	3·54	934199	1·25	774471	4·79	225529	15
46	708882	3·53	934123	1·25	774759	4·79	225241	14
47	709094	3·53	934048	1·25	775046	4·79	224954	13
48	709306	3·53	933973	1·25	775333	4·79	224667	12
49	709518	3·53	933898	1·26	775621	4·78	224379	11
50	709730	3·53	933822	1·26	775908	4·78	224092	10
51	9·709941	3·52	9·933747	1·26	9·776195	4·78	10·223805	9
52	710153	3·52	933671	1·26	776482	4·78	223518	8
53	710364	3·52	933596	1·26	776769	4·78	223231	7
54	710575	3·52	933520	1·26	777055	4·78	222945	6
55	710786	3·51	933445	1·26	777342	4·78	222658	5
56	710997	3·51	933369	1·26	777628	4·77	222372	4
57	711208	3·51	933293	1·26	777915	4·77	222085	3
58	711419	3·51	933217	1·26	778201	4·77	221799	2
59	711629	3·50	933141	1·26	778487	4·77	221512	1
60	711839	3·50	933066	1·26	778774	4·77	221226	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(59 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·711839	3·50	9·933066	1·26	9·778774	4·77	10·221226	60
1	712050	3·50	932990	1·27	779060	4·77	220940	59
2	712260	3·50	932914	1·27	779346	4·76	220654	58
3	712469	3·49	932838	1·27	779632	4·76	220368	57
4	712679	3·49	932762	1·27	779918	4·76	220082	56
5	712889	3·49	932685	1·27	780203	4·76	219797	55
6	713098	3·49	932609	1·27	780489	4·76	219511	54
7	713308	3·49	932533	1·27	780775	4·76	219225	53
8	713517	3·48	932457	1·27	781060	4·76	218940	52
9	713726	3·48	932380	1·27	781346	4·75	218654	51
10	713935	3·48	932304	1·27	781631	4·75	218369	50
11	9·714144	3·48	9·932228	1·27	9·781916	4·75	10·218084	49
12	714352	3·47	932151	1·27	782201	4·75	217799	48
13	714561	3·47	932075	1·28	782486	4·75	217514	47
14	714769	3·47	931998	1·28	782771	4·75	217229	46
15	714978	3·47	931921	1·28	783056	4·75	216944	45
16	715186	3·47	931845	1·28	783341	4·75	216659	44
17	715394	3·46	931768	1·28	783626	4·74	216374	43
18	715602	3·46	931691	1·28	783910	4·74	216090	42
19	715809	3·46	931614	1·28	784195	4·74	215805	41
20	716017	3·46	931537	1·28	784479	4·74	215521	40
21	9·716224	3·45	9·931460	1·28	9·784764	4·74	10·215236	39
22	716432	3·45	931383	1·28	785048	4·74	214952	38
23	716639	3·45	931306	1·28	785332	4·73	214668	37
24	716846	3·45	931229	1·29	785616	4·73	214384	36
25	717053	3·45	931152	1·29	785900	4·73	214100	35
26	717259	3·44	931075	1·29	786184	4·73	213816	34
27	717466	3·44	930998	1·29	786468	4·73	213532	33
28	717673	3·44	930921	1·29	786752	4·73	213248	32
29	717879	3·44	930843	1·29	787036	4·73	212964	31
30	718085	3·43	930766	1·29	787319	4·72	212681	30
31	9·718291	3·43	9·930688	1·29	9·787603	4·72	10·212397	29
32	718497	3·43	930611	1·29	787886	4·72	212114	28
33	718703	3·43	930533	1·29	788170	4·72	211830	27
34	718909	3·43	930456	1·29	788453	4·72	211547	26
35	719114	3·42	930378	1·29	788736	4·72	211264	25
36	719320	3·42	930300	1·30	789019	4·72	210981	24
37	719525	3·42	930223	1·30	789302	4·71	210698	23
38	719730	3·42	930145	1·30	789585	4·71	210415	22
39	719935	3·41	930067	1·30	789868	4·71	210132	21
40	720140	3·41	929989	1·30	790151	4·71	209849	20
41	9·720345	3·41	9·929911	1·30	9·790433	4·71	10·209567	19
42	720549	3·41	929833	1·30	790716	4·71	209284	18
43	720754	3·40	929755	1·30	790999	4·71	209001	17
44	720958	3·40	929677	1·30	791281	4·71	208719	16
45	721162	3·40	929599	1·30	791563	4·70	208437	15
46	721366	3·40	929521	1·30	791846	4·70	208154	14
47	721570	3·40	929442	1·30	792128	4·70	207872	13
48	721774	3·39	929364	1·31	792410	4·70	207590	12
49	721978	3·39	929286	1·31	792692	4·70	207308	11
50	722181	3·39	929207	1·31	792974	4·70	207026	10
51	9·722385	3·39	9·929129	1·31	9·793256	4·70	10·206744	9
52	722588	3·39	929050	1·31	793538	4·69	206462	8
53	722791	3·38	928972	1·31	793819	4·69	206181	7
54	722994	3·38	928893	1·31	794101	4·69	205899	6
55	723197	3·38	928815	1·31	794383	4·69	205617	5
56	723400	3·38	928736	1·31	794664	4·69	205336	4
57	723603	3·37	928657	1·31	794945	4·69	205055	3
58	723805	3·37	928578	1·31	795227	4·69	204773	2
59	724007	3·37	928499	1·31	795508	4·68	204492	1
60	724210	3·37	928420	1·31	795789	4·68	204211	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(58 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·724210	3·37	9·928420	1·32	9·795789	4·68	10·204211	60
1	724412	3·37	928342	1·32	796070	4·68	203930	59
2	724614	3·36	928263	1·32	796351	4·68	203649	58
3	724816	3·36	928183	1·32	796632	4·68	203368	57
4	725017	3·36	928104	1·32	796913	4·68	203087	56
5	725219	3·36	928025	1·32	797194	4·68	202806	55
6	725420	3·35	927946	1·32	797475	4·68	202525	54
7	725622	3·35	927867	1·32	797755	4·68	202245	53
8	725823	3·35	927787	1·32	798036	4·67	201964	52
9	726024	3·35	927708	1·32	798316	4·67	201684	51
10	726225	3·35	927629	1·32	798596	4·67	201404	50
11	9·726426	3·34	9·927549	1·32	9·798877	4·67	10·201123	49
12	726626	3·34	927470	1·33	799157	4·67	200843	48
13	726827	3·34	927390	1·33	799437	4·67	200563	47
14	727027	3·34	927310	1·33	799717	4·67	200283	46
15	727228	3·34	927231	1·33	799997	4·66	200003	45
16	727428	3·33	927151	1·33	800277	4·66	199723	44
17	727628	3·33	927071	1·33	800557	4·66	199443	43
18	727828	3·33	926991	1·33	800836	4·66	199164	42
19	728027	3·33	926911	1·33	801116	4·66	198884	41
20	728227	3·33	926831	1·33	801396	4·66	198604	40
21	9·728427	3·32	9·926751	1·33	9·801675	4·66	10·198325	39
22	728626	3·32	926671	1·33	801955	4·66	198045	38
23	728825	3·32	926591	1·33	802234	4·65	197766	37
24	729024	3·32	926511	1·34	802513	4·65	197487	36
25	729223	3·31	926431	1·34	802792	4·65	197208	35
26	729422	3·31	926351	1·34	803072	4·65	196928	34
27	729621	3·31	926270	1·34	803351	4·65	196649	33
28	729820	3·31	926190	1·34	803630	4·65	196370	32
29	730018	3·30	926110	1·34	803908	4·65	196092	31
30	730216	3·30	926029	1·34	804187	4·65	195813	30
31	9·730415	3·30	9·925949	1·34	9·804466	4·64	10·195534	29
32	730613	3·30	925868	1·34	804745	4·64	195255	28
33	730811	3·30	925788	1·34	805023	4·64	194977	27
34	731009	3·29	925707	1·34	805302	4·64	194698	26
35	731206	3·29	925626	1·34	805580	4·64	194420	25
36	731404	3·29	925545	1·35	805859	4·64	194141	24
37	731602	3·29	925465	1·35	806137	4·64	193863	23
38	731799	3·29	925384	1·35	806415	4·63	193585	22
39	731996	3·28	925303	1·35	806693	4·63	193307	21
40	732193	3·28	925222	1·35	806971	4·63	193029	20
41	9·732390	3·28	9·925141	1·35	9·807249	4·63	10·192751	19
42	732587	3·28	925060	1·35	807527	4·63	192473	18
43	732784	3·28	924979	1·35	807805	4·63	192195	17
44	732980	3·27	924897	1·35	808083	4·63	191917	16
45	733177	3·27	924816	1·35	808361	4·63	191639	15
46	733373	3·27	924735	1·36	808638	4·62	191362	14
47	733569	3·27	924654	1·36	808916	4·62	191084	13
48	733765	3·27	924572	1·36	809193	4·62	190807	12
49	733961	3·26	924491	1·36	809471	4·62	190529	11
50	734157	3·26	924409	1·36	809748	4·62	190252	10
51	9·734353	3·26	9·924328	1·36	9·810025	4·62	10·189975	9
52	734549	3·26	924246	1·36	810302	4·62	189698	8
53	734744	3·25	924164	1·36	810580	4·62	189420	7
54	734939	3·25	924083	1·36	810857	4·62	189143	6
55	735135	3·25	924001	1·36	811134	4·61	188866	5
56	735330	3·25	923919	1·36	811410	4·61	188590	4
57	735525	3·25	923837	1·36	811687	4·61	188313	3
58	735719	3·24	923755	1·37	811964	4·61	188036	2
59	735914	3·24	923673	1·37	812241	4·61	187759	1
60	736109	3·24	923591	1·37	812517	4·61	187483	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(57 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·736109	3·24	9·923591	1·37	9·812517	4·61	10·187482	60
1	736303	3·24	923509	1·37	812794	4·61	187206	59
2	736498	3·24	923427	1·37	813070	4·61	186930	58
3	736692	3·23	923345	1·37	813347	4·60	186653	57
4	736886	3·23	923263	1·37	813623	4·60	186377	56
5	737080	3·23	923181	1·37	813899	4·60	186101	55
6	737274	3·23	923098	1·37	814175	4·60	185825	54
7	737467	3·23	923016	1·37	814452	4·60	185548	53
8	737661	3·22	922933	1·37	814728	4·60	185272	52
9	737855	3·22	922851	1·37	815004	4·60	184996	51
10	738048	3·22	922768	1·38	815279	4·60	184721	50
11	9·738241	3·22	9·922686	1·38	9·815555	4·59	10·184445	49
12	738434	3·22	922603	1·38	815831	4·59	184169	48
13	738627	8·21	922520	1·38	816107	4·59	183893	47
14	738820	3·21	922438	1·38	816382	4·59	183618	46
15	739013	3·21	922355	1·38	816658	4·59	183342	45
16	739206	3·21	922272	1·38	816933	4·59	183067	44
17	739398	3·21	922189	1·38	817209	4·59	182791	43
18	739590	3·20	922106	1·38	817484	4·59	182516	42
19	739783	3·20	922023	1·38	817759	4·59	182241	41
20	739975	3·20	921940	1·38	818035	4·58	181965	40
21	9·740167	3·20	9·921857	1·39	9·818310	4·58	10·181690	39
22	740359	3·20	921774	1·39	818585	4·58	181415	38
23	740550	3·19	921691	1·39	818860	4·58	181140	37
24	740742	3·19	921607	1·39	819135	4·58	180865	36
25	740934	3·19	921524	1·39	819410	4·58	180590	35
26	741125	3·19	921441	1·39	819684	4·58	180316	34
27	741316	3·19	921357	1·39	819959	4·58	180041	33
28	741508	3·18	921274	1·39	820234	4·58	179766	32
29	741699	3·18	921190	1·39	820508	4·57	179492	31
30	741889	3·18	921107	1·39	820783	4·57	179217	30
31	9·742080	3·18	9·921023	1·39	9·821057	4·57	10·178943	29
32	742271	3·18	920939	1·40	821332	4·57	178668	28
33	742462	3·17	920856	1·40	821606	4·57	178394	27
34	742652	3·17	920772	1·40	821880	4·57	178120	26
35	742842	3·17	920688	1·40	822154	4·57	177846	25
36	743033	3·17	920604	1·40	822429	4·57	177571	24
37	743223	3·17	920520	1·40	822703	4·57	177297	23
38	743413	3·16	920436	1·40	822977	4·56	177023	22
39	743602	3·16	920352	1·40	823250	4·56	176750	21
40	743792	3·16	920268	1·40	823524	4·56	176476	20
41	9·743982	3·16	9·920184	1·40	9·823798	4·56	10·176202	19
42	744171	3·16	920099	1·40	824072	4·56	175928	18
43	744361	3·15	920015	1·40	824345	4·56	175655	17
44	744550	3·15	919931	1·41	824619	4·56	175381	16
45	744739	3·15	919846	1·41	824893	4·56	175107	15
46	744928	3·15	919762	1·41	825166	4·56	174834	14
47	745117	3·15	919677	1·41	825439	4·55	174561	13
48	745306	3·14	919593	1·41	825713	4·55	174287	12
49	745494	3·14	919508	1·41	825986	4·55	174014	11
50	745683	3·14	919424	1·41	826259	4·55	173741	10
51	9·745871	3·14	9·919339	1·41	9·826532	4·55	10·173468	9
52	746059	3·14	919254	1·41	826805	4·55	173195	8
53	746248	3·13	919169	1·41	827078	4·55	172922	7
54	746436	4·13	919085	1·41	827351	4·55	172649	6
55	746624	3·13	919000	1·41	827624	4·55	172376	5
56	746812	3·13	918915	1·42	827897	4·54	172103	4
57	746999	3·13	918830	1·42	828170	4·54	171830	3
58	747187	3·12	918745	1·42	828442	4·54	171558	2
59	747374	3·12	918659	1·42	828715	4·54	171285	1
60	747562	3·12	918574	1·42	828987	4·54	171013	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·747562	3·12	9·918574	1·42	9·828987	4·54	10·171013	60
1	747749	3·12	918489	1·42	829260	4·54	170740	59
2	747936	3·12	918404	1·42	829532	4·54	170468	58
3	748123	3·11	918318	1·42	829805	4·54	170195	57
4	748310	3·11	918233	1·42	830077	4·54	169923	56
5	748497	3·11	918147	1·42	830349	4·53	169651	55
6	748683	3·11	918062	1·42	830621	4·53	169379	54
7	748870	3·11	917976	1·43	830893	4·53	169107	53
8	749056	3·10	917891	1·43	831165	4·53	168835	52
9	749243	3·10	917805	1·43	831437	4·53	168563	51
10	749429	3·10	917719	1·43	831709	4·53	168291	50
11	9·749615	3·10	9·917634	1·43	9·831981	4·53	10·168019	49
12	749801	3·10	917548	1·43	832253	4·53	167747	48
13	749987	3·09	917462	1·43	832525	4·53	167475	47
14	750172	3·09	917376	1·43	832796	4·53	167204	46
15	750358	3·09	917290	1·43	833068	4·52	166932	45
16	750543	3·09	917204	1·43	833339	4·52	166661	44
17	750729	3·09	917118	1·44	833611	4·52	166389	43
18	750914	3·08	917032	1·44	833882	4·52	166118	42
19	751099	3·08	916946	1·44	834154	4·52	165846	41
20	751284	3·08	916859	1·44	834425	4·52	165575	40
21	9·751469	3·08	9·916773	1·44	9·834696	4·52	10·165304	39
22	751654	3·08	916687	1·44	834967	4·52	165033	38
23	751839	3·08	916600	1·44	835238	4·52	164762	37
24	752023	3·07	916514	1·44	835509	4·52	164491	36
25	752208	3·07	916427	1·44	835780	4·51	164220	35
26	752392	3·07	916341	1·44	836051	4·51	163949	34
27	752576	3·07	916254	1·44	836322	4·51	163678	33
28	752760	3·07	916167	1·45	836593	4·51	163407	32
29	752944	3·06	916081	1·45	836864	4·51	163136	31
30	753128	3·06	915994	1·45	837134	4·51	162866	30
31	9·753312	3·06	9·915907	1·45	9·837405	4·51	10·162595	29
32	753495	3·06	915820	1·45	837675	4·51	162325	28
33	753679	3·06	915733	1·45	837946	4·51	162054	27
34	753862	3·05	915646	1·45	838216	4·51	161784	26
35	754046	3·05	915559	1·45	838487	4·50	161513	25
36	754229	3·05	915472	1·45	838757	4·50	161243	24
37	754412	3·05	915385	1·45	839027	4·50	160973	23
38	754595	3·05	915297	1·45	839297	4·50	160703	22
39	754778	3·04	915210	1·45	839568	4·50	160432	21
40	754960	3·04	915123	1·46	839838	4·50	160162	20
41	9·755143	3·04	9·915035	1·46	9·840108	4·50	10·159892	19
42	755326	3·04	914948	1·46	840378	4·50	159622	18
43	755508	3·04	914860	1·46	840647	4·50	159353	17
44	755690	3·04	914773	1·46	840917	4·49	159083	16
45	755872	3·03	914685	1·46	841187	4·49	158813	15
46	756054	3·03	914598	1·46	841457	4·49	158543	14
47	756236	3·03	914510	1·46	841726	4·49	158274	13
48	756418	3·03	914422	1·46	841996	4·49	158004	12
49	756600	3·03	914334	1·46	842266	4·49	157734	11
50	756782	3·02	914246	1·47	842535	4·49	157465	10
51	9·756963	3·02	9·914158	1·47	9·842805	4·49	10·157195	9
52	757144	3·02	914070	1·47	843074	4·49	156926	8
53	757326	3·02	913982	1·47	843343	4·49	156657	7
54	757507	3·02	913894	1·47	843612	4·49	156388	6
55	757688	3·01	913806	1·47	843882	4·48	156118	5
56	757869	3·01	913718	1·47	844151	4·48	155849	4
57	758050	3·01	913630	1·47	844420	4·48	155580	3
58	758230	3·01	913541	1·47	844689	4·48	155311	2
59	758411	3·01	913453	1·47	844958	4·48	155042	1
60	758591	3·01	913365	1·47	845227	4·48	154773	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(55 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·758591	3·01	9·913365	1·47	9·845227	4·48	10·154773	60
1	758772	3·00	913276	1·47	845496	4·48	154504	59
2	758952	3·00	913187	1·48	845764	4·48	154236	58
3	759132	3·00	913099	1·48	846033	4·48	153967	57
4	759312	3·00	913010	1·48	846302	4·48	153698	56
5	759492	3·00	912922	1·48	846570	4·47	153430	55
6	759672	2·99	912833	1·48	846839	4·47	153161	54
7	759852	2·99	912744	1·48	847107	4·47	152893	53
8	760031	2·99	912655	1·48	847376	4·47	152624	52
9	760211	2·99	912566	1·48	847644	4·47	152356	51
10	760390	2·99	912477	1·48	847913	4·47	152087	50
11	9·760569	2·98	9·912388	1·48	9·848181	4·47	10·151819	49
12	760748	2·98	912299	1·49	848449	4·47	151551	48
13	760927	2·98	912210	1·49	848717	4·47	151283	47
14	761106	2·98	912121	1·49	848986	4·47	151014	46
15	761285	2·98	912031	1·49	849254	4·47	150746	45
16	761464	2·98	911942	1·49	849522	4·47	150478	44
17	761642	2·97	911853	1·49	849790	4·46	150210	43
18	761821	2·97	911763	1·49	850058	4·46	149942	42
19	761999	2·97	911674	1·49	850325	4·46	149675	41
20	762177	2·97	911584	1·49	850593	4·46	149407	40
21	9·762356	2·97	9·911495	1·49	9·850861	4·46	10·149139	39
22	762534	2·96	911405	1·49	851129	4·46	148871	38
23	762712	2·96	911315	1·50	851396	4·46	148604	37
24	762889	2·96	911226	1·50	851664	4·46	148336	36
25	763067	2·96	911136	1·50	851931	4·46	148069	35
26	763245	2·96	911046	1·50	852199	4·46	147801	34
27	763422	2·96	910956	1·50	852466	4·46	147534	33
28	763600	2·95	910866	1·50	852733	4·45	147267	32
29	763777	2·95	910776	1·50	853001	4·45	146999	31
30	763954	2·95	910686	1·50	853268	4·45	146732	30
31	9·764131	2·95	9·910596	1·50	9·853535	4·45	10·146465	29
32	764308	2·95	910506	1·50	853802	4·45	146198	28
33	764485	2·94	910415	1·50	854069	4·45	145931	27
34	764662	2·94	910325	1·51	854336	4·45	145664	26
35	764838	2·94	910235	1·51	854603	4·45	145397	25
36	765015	2·94	910144	1·51	854870	4·45	145130	24
37	765191	2·94	910054	1·51	855137	4·45	144863	23
38	765367	2·94	909963	1·51	855404	4·45	144596	22
39	765544	2·93	909873	1·51	855671	4·44	144329	21
40	765720	2·93	909782	1·51	855938	4·44	144062	20
41	9·765896	2·93	9·909691	1·51	9·856204	4·44	10·143796	19
42	766072	2·93	909601	1·51	856471	4·44	143529	18
43	766247	2·93	909510	1·51	856737	4·44	143263	17
44	766423	2·93	909419	1·51	857004	4·44	142996	16
45	766598	2·92	909328	1·52	857270	4·44	142730	15
46	766774	2·92	909237	1·52	857537	4·44	142463	14
47	766949	2·92	909146	1·52	857803	4·44	142197	13
48	767124	2·92	909055	1·52	858069	4·44	141931	12
49	767300	2·92	908964	1·52	858336	4·44	141664	11
50	767475	2·91	908873	1·52	858602	4·43	141398	10
51	9·767649	2·91	9·908781	1·52	9·858868	4·43	10·141132	9
52	767824	2·91	908690	1·52	859134	4·43	140866	8
53	767999	2·91	908599	1·52	859400	4·43	140600	7
54	768173	2·91	908507	1·52	859666	4·43	140334	6
55	768348	2·90	908416	1·53	859932	4·43	140068	5
56	768522	2·90	908324	1·53	860198	4·43	139802	4
57	768697	2·90	908233	1·53	860464	4·43	139536	3
58	768871	2·90	908141	1·53	860730	4·43	139270	2
59	769045	2·90	908049	1·53	860995	4·43	139005	1
60	769219	2·90	907958	1·53	861261	4·43	138739	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M

(54 DEGREES.)

M.	Sine	D	Cosine	D.	Tang.	D.	Cotang.	
0	9·769219	2·90	9·907958	1·53	9·861261	4·43	10·138739	60
1	769393	2·89	907866	1·53	861527	4·43	138473	59
2	769566	2·89	907774	1·53	861792	4·42	138208	58
3	769740	2·89	907682	1·53	862058	4·42	137942	57
4	769913	2·89	907590	1·53	862323	4·42	137677	56
5	770087	2·89	907498	1·53	862589	4·42	137411	55
6	770260	2·88	907406	1·53	862854	4·42	137146	54
7	770433	2·88	907314	1·54	863119	4·42	136881	53
8	770606	2·88	907222	1·54	863385	4·42	136615	52
9	770779	2·88	907129	1·54	863650	4·42	136350	51
10	770952	2·88	907037	1·54	863915	4·42	136085	50
11	9·771125	2·88	9·906945	1·54	9·864180	4·42	10·135820	49
12	771298	2·87	906852	1·54	864445	4·42	135555	48
13	771470	2·87	906760	1·54	864710	4·42	135290	47
14	771643	2·87	906667	1·54	864975	4·41	135025	46
15	771815	2·87	906575	1·54	865240	4·41	134760	45
16	771987	2·87	906482	1·54	865505	4·41	134495	44
17	772159	2·87	906389	1·55	865770	4·41	134230	43
18	772331	2·86	906296	1·55	866035	4·41	133965	42
19	772503	2·86	906204	1·55	866300	4·41	133700	41
20	772675	2·86	906111	1·55	866564	4·41	133436	40
21	9·772847	2·86	9·906018	1·55	9·866829	4·41	10·133171	39
22	773018	2·86	905925	1·55	867094	4·41	132906	38
23	773190	2·86	905832	1·55	867358	4·41	132642	37
24	773361	2·85	905739	1·55	867623	4·41	132377	36
25	773533	2·85	905645	1·55	867887	4·41	132113	35
26	773704	2·85	905552	1·55	868152	4·40	131848	34
27	773875	2·85	905459	1·55	868416	4·40	131584	33
28	774046	2·85	905366	1·56	868680	4·40	131320	32
29	774217	2·85	905272	1·56	868945	4·40	131055	31
30	774388	2·84	905179	1·56	869209	4·40	130794	30
31	9·774558	2·84	9·905085	1·56	9·869473	4·40	10·130527	29
32	774729	2·84	904992	1·56	869737	4·40	130263	28
33	774899	2·84	904898	1·56	870001	4·40	129999	27
34	775070	2·84	904804	1·56	870265	4·40	129735	26
35	775240	2·84	904711	1·56	870529	4·40	129471	25
36	775410	2·83	904617	1·56	870793	4·40	129207	24
37	775580	2·83	904523	1·56	871057	4·40	128943	23
38	775750	2·83	904429	1·57	871321	4·40	128679	22
39	775920	2·83	904335	1·57	871585	4·40	128415	21
40	776090	2·83	904241	1·57	871849	4·39	128151	20
41	9·776259	2·83	9·904147	1·57	9·872112	4·39	10·127888	19
42	776429	2·82	904053	1·57	872376	4·39	127624	18
43	776598	2·82	903959	1·57	872640	4·39	127360	17
44	776768	2·82	903864	1·57	872903	4·39	127097	16
45	776937	2·82	903770	1·57	873167	4·39	126833	15
46	777106	2·82	903676	1·57	873430	4·39	126570	14
47	777275	2·81	903581	1·57	873694	4·39	126306	13
48	777444	2·81	903487	1·57	873957	4·39	126043	12
49	777613	2·81	903392	1·58	874220	4·39	125780	11
50	777781	2·81	903298	1·58	874484	4·39	125516	10
51	9·777950	2·81	9·903203	1·58	9·874747	4·39	10·125253	9
52	778119	2·81	903108	1·58	875010	4·39	124990	8
53	778287	2·80	903014	1·58	875273	4·38	124727	7
54	778455	2·80	902919	1·58	875536	4·38	124464	6
55	778624	2·80	902824	1·58	875800	4·38	124200	5
56	778792	2·80	902729	1·58	876063	4·38	123937	4
57	778960	2·80	902634	1·58	876326	4·38	123674	3
58	779128	2·80	902539	1·59	876589	4·38	123411	2
59	779295	2·79	902444	1·59	876851	4·38	123149	1
60	779463	2·79	902349	1·59	877114	4·38	122886	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(53 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·779463	2·79	9·902349	1·59	9·877114	4·38	10·122886	60
1	779631	2·79	902253	1·59	877377	4·38	122623	59
2	779798	2·79	902158	1·59	877640	4·38	122360	58
3	779966	2·79	902063	1·59	877903	4·38	122097	57
4	780133	2·79	901967	1·59	878165	4·38	121835	56
5	780300	2·78	901872	1·59	878428	4·38	121572	55
6	780467	2·78	901776	1·59	878691	4·38	121309	54
7	780634	2·78	901681	1·59	878953	4·37	121047	53
8	780801	2·78	901585	1·59	879216	4·37	120784	52
9	780968	2·78	901490	1·59	879478	4·37	120522	51
10	781134	2·78	901394	1·60	879741	4·37	120259	50
11	9·781301	2·77	9·901298	1·60	9·880003	4·37	10·119997	49
12	781468	2·77	901202	1·60	880265	4·37	119735	48
13	781634	2·77	901106	1·60	880528	4·37	119472	47
14	781800	2·77	901010	1·60	880790	4·37	119210	46
15	781966	2·77	900914	1·60	881052	4·37	118948	45
16	782132	2·77	900818	1·60	881314	4·37	118686	44
17	782298	2·76	900722	1·60	881576	4·37	118424	43
18	782464	2·76	900626	1·60	881839	4·37	118161	42
19	782630	2·76	900529	1·60	882101	4·37	117899	41
20	782796	2·76	900433	1·61	882363	4·36	117637	40
21	9·782961	2·76	9·900337	1·61	9·882625	4·36	10·117375	39
22	783127	2·76	900240	1·61	882887	4·36	117113	38
23	783292	2·75	900144	1·61	883148	4·36	116852	37
24	783458	2·75	900047	1·61	883410	4·36	116590	36
25	783623	2·75	899951	1·61	883672	4·36	116328	35
26	783788	2·75	899854	1·61	883934	4·36	116066	34
27	783953	2·75	899757	1·61	884196	4·36	115804	33
28	784118	2·75	899660	1·61	884457	4·36	115543	32
29	784282	2·74	899564	1·61	884719	4·36	115281	31
30	784447	2·74	899467	1·62	884980	4·36	115020	30
31	9·784612	2·74	9·899370	1·62	9·885242	4·36	10·114758	29
32	784776	2·74	899273	1·62	885503	4·36	114497	28
33	784941	2·74	899176	1·62	885765	4·36	114235	27
34	785105	2·74	899078	1·62	886026	4·36	113974	26
35	785269	2·73	898981	1·62	886288	4·36	113712	25
36	785433	2·73	898884	1·62	886549	4·35	113451	24
37	785597	2·73	898787	1·62	886810	4·35	113190	23
38	785761	2·73	898689	1·62	887072	4·35	112928	22
39	785925	2·73	898592	1·62	887333	4·35	112667	21
40	786089	2·73	898494	1·63	887594	4·35	112406	20
41	9·786252	2·72	9·898397	1·63	9·887855	4·35	10·112145	19
42	786416	2·72	898299	1·63	888116	4·35	111884	18
43	786579	2·72	898202	1·63	888377	4·35	111623	17
44	786742	2·72	898104	1·63	888639	4·35	111361	16
45	786906	2·72	898006	1·63	888900	4·35	111100	15
46	787069	2·72	897908	1·63	889160	4·35	110840	14
47	787232	2·71	897810	1·63	889421	4·35	110579	13
48	787395	2·71	897712	1·63	889682	4·35	110318	12
49	787557	2·71	897614	1·63	889943	4·35	110057	11
50	787720	2·71	897516	1·63	890204	4·34	109796	10
51	9·787883	2·71	9·897418	1·64	9·890465	4·34	10·109535	9
52	788045	2·71	897320	1·64	890725	4·34	109275	8
53	788208	2·71	897222	1·64	890986	4·34	109014	7
54	788370	2·70	897123	1·64	891247	4·34	108753	6
55	788532	2·70	897025	1·64	891507	4·34	108493	5
56	788694	2·70	896926	1·64	891768	4·34	108232	4
57	788856	2·70	896828	1·64	892028	4·34	107972	3
58	789018	2·70	896729	1·64	892289	4·34	107711	2
59	789180	2·70	896631	1·64	892549	4·34	107451	1
60	789342	2·69	896532	1·64	892810	4·34	107190	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(52 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·789342	2·69	9·896532	1·64	9·892810	4·34	10·107190	60
1	789504	2·69	896433	1·65	893070	4·34	106930	59
2	789665	2·69	896335	1·65	893331	4·34	106669	58
3	789827	2·69	896236	1·65	893591	4·34	106409	57
4	789988	2·69	896137	1·65	893851	4·34	106149	56
5	790149	2·69	896038	1·65	894111	4·34	105889	55
6	790310	2·68	895939	1·65	894371	4·34	105629	54
7	790471	2·68	895840	1·65	894632	4·33	105368	53
8	790632	2·68	895741	1·65	894892	4·33	105108	52
9	790793	2·68	895641	1·65	895152	4·33	104848	51
10	790954	2·68	895542	1·65	895412	4·33	104588	50
11	9·791115	2·68	9·895443	1·66	9·895672	4·33	10·104328	49
12	791275	2·67	895343	1·66	895932	4·33	104068	48
13	791436	2·67	895244	1·66	896192	4·33	103808	47
14	791596	2·67	895145	1·66	896452	4·33	103548	46
15	791757	2·67	895045	1·66	896712	4·33	103288	45
16	791917	2·67	894945	1·66	896971	4·33	103029	44
17	792077	2·67	894846	1·66	897231	4·33	102769	43
18	792237	2·66	894746	1·66	897491	4·33	102509	42
19	792397	2·66	894646	1·66	897751	4·33	102249	41
20	792557	2·66	894546	1·66	898010	4·33	101990	40
21	9·792716	2·66	9·894446	1·67	9·898270	4·33	10·101730	39
22	792876	2·66	894346	1·67	898530	4·33	101470	38
23	793035	2·66	894246	1·67	898789	4·33	101211	37
24	793195	2·65	894146	1·67	899049	4·32	100951	36
25	793354	2·65	894046	1·67	899308	4·32	100692	35
26	793514	2·65	893946	1·67	899568	4·32	100432	34
27	793673	2·65	893846	1·67	899827	4·32	100173	33
28	793832	2·65	893745	1·67	900086	4·32	099914	32
29	793991	2·65	893645	1·67	900346	4·32	099654	31
30	794150	2·64	893544	1·67	900605	4·32	099395	30
31	9·794308	2·64	9·893444	1·68	9·900864	4·32	10·099136	29
32	794467	2·64	893343	1·68	901124	4·32	098876	28
33	794626	2·64	893243	1·68	901383	4·32	098617	27
34	794784	2·64	893142	1·68	901642	4·32	098358	26
35	794942	2·64	893041	1·68	901901	4·32	098099	25
36	795101	2·64	892940	1·68	902160	4·32	097840	24
37	795259	2·63	892839	1·68	902419	4·32	097581	23
38	795417	2·63	892739	1·68	902679	4·32	097321	22
39	795575	2·63	892638	1·68	902938	4·32	097062	21
40	795733	2·63	892536	1·68	903197	4·31	096803	20
41	9·795891	2·63	9·892435	1·69	9·903455	4·31	10·096545	19
42	796049	2·63	892334	1·69	903714	4·31	096286	18
43	796206	2·63	892233	1·69	903973	4·31	096027	17
44	796364	2·62	892132	1·69	904232	4·31	095768	16
45	796521	2·62	892030	1·69	904491	4·31	095509	15
46	796679	2·62	891929	1·69	904750	4·31	095250	14
47	796836	2·62	891827	1·69	905008	4·31	094992	13
48	796993	2·62	891726	1·69	905267	4·31	094733	12
49	797150	2·61	891624	1·69	905526	4·31	094474	11
50	797307	2·61	891523	1·70	905784	4·31	094216	10
51	9·797464	2·61	9·891421	1·70	9·906043	4·31	10·093957	9
52	797621	2·61	891319	1·70	906302	4·31	093698	8
53	797777	2·61	891217	1·70	906560	4·31	093440	7
54	797934	2·61	891115	1·70	906819	4·31	093181	6
55	798091	2·61	891013	1·70	907077	4·31	092923	5
56	798247	2·61	890911	1·70	907336	4·31	092664	4
57	798403	2·60	890809	1·70	907594	4·31	092406	3
58	798560	2·60	890707	1·70	907852	4·31	092148	2
59	798716	2·60	890605	1·70	908111	4·30	091889	1
60	798872	2·60	890503	1·70	908369	4·30	091631	0
	Cosine	D.	Sine	D.	Cotang.	D.	**Tang.**	M.

(51 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·798872	2·60	9·890503	1·70	9·908369	4·30	10·091631	60
1	799028	2·60	890400	1·71	908628	4·30	091372	59
2	799184	2·60	890298	1·71	908886	4·30	091114	58
3	799339	2·59	890195	1·71	909144	4·30	090856	57
4	799495	2·59	890093	1·71	909402	4·30	090598	56
5	799651	2·59	889990	1·71	909660	4·30	090340	55
6	799806	2·59	889888	1·71	909918	4·30	090082	54
7	799962	2·59	889785	1·71	910177	4·30	089823	53
8	800117	2·59	889682	1·71	910435	4·30	089565	52
9	800272	2·58	889579	1·71	910693	4·30	089307	51
10	800427	2·58	889477	1·71	910951	4·30	089049	50
11	9·800582	2·58	9·889374	1·72	9·911209	4·30	10·088791	49
12	800737	2·58	889271	1·72	911467	4·30	088533	48
13	800892	2·58	889168	1·72	911724	4·30	088276	47
14	801047	2·58	889064	1·72	911982	4·30	088018	46
15	801201	2·58	888961	1·72	912240	4·30	087760	45
16	801356	2·57	888858	1·72	912498	4·30	087502	44
17	801511	2·57	888755	1·72	912756	4·30	087244	43
18	801665	2·57	888651	1·72	913014	4·29	086986	42
19	801819	2·57	888548	1·72	913271	4·29	086729	41
20	801973	2·57	888444	1·73	913529	4·29	086471	40
21	9·802128	2·57	9·888341	1·73	9·913787	4·29	10·086213	39
22	802282	2·56	888237	1·73	914044	4·29	085956	38
23	802436	2·56	888134	1·73	914302	4·29	085698	37
24	802589	2·56	888030	1·73	914560	4·29	085440	36
25	802743	2·56	887926	1·73	914817	4·29	085183	35
26	802897	2·56	887822	1·73	915075	4·29	084925	34
27	803050	2·56	887718	1·73	915332	4·29	084668	33
28	803204	2·56	887614	1·73	915590	4·29	084410	32
29	803357	2·55	887510	1·73	915847	4·29	084153	31
30	803511	2·55	887406	1·74	916104	4·29	083896	30
31	9·803664	2·55	9·887302	1·74	9·916362	4·29	10·083638	29
32	803817	2·55	887198	1·74	916619	4·29	083381	28
33	803970	2·55	887093	1·74	916877	4·29	083123	27
34	804123	2·55	886989	1·74	917134	4·29	082866	26
35	804276	2·54	886885	1·74	917391	4·29	082609	25
36	804428	2·54	886780	1·74	917648	4·29	082352	24
37	804581	2·54	886676	1·74	917905	4·29	082095	23
38	804734	2·54	886571	1·74	918163	4·28	081837	22
39	804886	2·54	886466	1·74	918420	4·28	081580	21
40	805039	2·54	886362	1·75	918677	4·28	081323	20
41	9·805191	2·54	9·886257	1·75	9·918934	4·28	10·081066	19
42	805343	2·53	886152	1·75	919191	4·28	080809	18
43	805495	2·53	886047	1·75	919448	4·28	080552	17
44	805647	2·53	885942	1·75	919705	4·28	080295	16
45	805799	2·53	885837	1·75	919962	4·28	080038	15
46	805951	2·53	885732	1·75	920219	4·28	079781	14
47	806103	2·53	885627	1·75	920476	4·28	079524	13
48	806254	2·53	885522	1·75	920733	4·28	079267	12
49	806406	2·52	885416	1·75	920990	4·28	079010	11
50	806557	2·52	885311	1·76	921247	4·28	078753	10
51	9·806709	2·52	9·885205	1·76	9·921503	4·28	10·078497	9
52	806860	2·52	885100	1·76	921760	4·28	078240	8
53	807011	2·52	884994	1·76	922017	4·28	077983	7
54	807163	2·52	884889	1·76	922274	4·28	077726	6
55	807314	2·52	884783	1·76	922530	4·28	077470	5
56	807465	2·51	884677	1·76	922787	4·28	077213	4
57	807615	2·51	884572	1·76	923044	4·28	076956	3
58	807766	2·51	884466	1·76	923300	4·28	076700	2
59	807917	2·51	884360	1·76	923557	4·27	076443	1
60	808067	2·51	884254	1·77	923813	4·27	076187	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(50 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·808067	2·51	9·884254	1·77	9·923813	4·27	10·076187	60
1	808218	2·51	884148	1·77	924070	4·27	075930	59
2	808368	2·51	884042	1·77	924327	4·27	075673	58
3	808519	2·50	883936	1·77	924583	4·27	075417	57
4	808669	2·50	883829	1·77	924840	4·27	075160	56
5	808819	2·50	883723	1·77	925096	4·27	074904	55
6	808969	2·50	883617	1·77	925352	4·27	074648	54
7	809119	2·50	883510	1·77	925609	4·27	074391	53
8	809269	2·50	883404	1·77	925865	4·27	074135	52
9	809419	2·49	883297	1·78	926122	4·27	073878	51
10	809569	2·49	883191	1·78	926378	4·27	073622	50
11	9·809718	2·49	9·883084	1·78	9·926634	4·27	10·073366	49
12	809868	2·49	882977	1·78	926890	4·27	073110	48
13	810017	2·49	882871	1·78	927147	4·27	072853	47
14	810167	2·49	882764	1·78	927403	4·27	072597	46
15	810316	2·48	882657	1·78	927659	4·27	072341	45
16	810465	2·48	882550	1·78	927915	4·27	072085	44
17	810614	2·48	882443	1·78	928171	4·27	071829	43
18	810763	2·48	882336	1·79	928427	4·27	071573	42
19	810912	2·48	882229	1·79	928683	4·27	071317	41
20	811061	2·48	882121	1·79	928940	4·27	071060	40
21	9·811210	2·48	9·882014	1·79	9·929196	4·27	10·070804	39
22	811358	2·47	881907	1·79	929452	4·27	070548	38
23	811507	2·47	881799	1·79	929708	4·27	070292	37
24	811655	2·47	881692	1·79	929964	4·26	070036	36
25	811804	2·47	881584	1·79	930220	4·26	069780	35
26	811952	2·47	881477	1·79	930475	4·26	069525	34
27	812100	2·47	881369	1·79	930731	4·26	069269	33
28	812248	2·47	881261	1·80	930987	4·26	069013	32
29	812396	2·46	881153	1·80	931243	4·26	068757	31
30	812544	2·46	881046	1·80	931499	4·26	068501	30
31	9·812692	2·46	9·880938	1·80	9·931755	4·26	10·068245	29
32	812840	2·46	880830	1·80	932010	4·26	067990	28
33	812988	2·46	880722	1·80	932266	4·26	067734	27
34	813135	2·46	880613	1·80	932522	4·26	067478	26
35	813283	2·46	880505	1·80	932778	4·26	067222	25
36	813430	2·45	880397	1·80	933033	4·26	066967	24
37	813578	2·45	880289	1·81	933289	4·26	066711	23
38	813725	2·45	880180	1·81	933545	4·26	066455	22
39	813872	2·45	880072	1·81	933800	4·26	066200	21
40	814019	2·45	879963	1·81	934056	4·26	065944	20
41	9·814166	2·45	9·879855	1·81	9·934311	4·26	10·065689	19
42	814313	2·45	879746	1·81	934567	4·26	065433	18
43	814460	2·44	879637	1·81	934823	4·26	065177	17
44	814607	2·44	879529	1·81	935078	4·26	064922	16
45	814753	2·44	879420	1·81	935333	4·26	064667	15
46	814900	2·44	879311	1·81	935589	4·26	064411	14
47	815046	2·44	879202	1·82	935844	4·26	064156	13
48	815193	2·44	879093	1·82	936100	4·26	063900	12
49	815339	2·44	878984	1·82	936355	4·26	063645	1
50	815485	2·43	878875	1·82	936610	4·26	063390	0
51	9·815631	2·43	9·878766	1·82	9·936866	4·25	10·063134	9
52	815778	2·43	878656	1·82	937121	4·25	062879	8
53	815924	2·43	878547	1·82	937376	4·25	062624	7
54	816069	2·43	878438	1·82	937632	4·25	062368	6
55	816215	2·43	878328	1·82	937887	4·25	062113	5
56	816361	2·43	878219	1·83	938142	4·25	061858	4
57	816507	2·42	878109	1·83	938398	4·25	061602	3
58	816652	2·42	877999	1·83	938653	4·25	061347	2
59	816798	2·42	877890	1·83	938908	4·25	061092	1
60	816943	2·42	877780	1·83	939163	4·25	060837	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(49 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·816943	2·42	9·877780	1·83	9·939163	4·25	10·060837	60
1	817088	2·42	877670	1·83	939418	4·25	060582	59
2	817233	2·42	877560	1·83	939673	4·25	060327	58
3	817379	2·42	877450	1·83	939928	4·25	060072	57
4	817524	2·41	877340	1·83	940183	4·25	059817	56
5	817668	2·41	877230	1·84	940438	4·25	059562	55
6	817813	2·41	877120	1·84	940694	4·25	059306	54
7	817958	2·41	877010	1·84	940949	4·25	059051	53
8	818103	2·41	876899	1·84	941204	4·25	058796	52
9	818247	2·41	876789	1·84	941458	4·25	058542	51
10	818392	2·41	876678	1·84	941714	4·25	058286	50
11	9·818536	2·40	9·876568	1·84	9·941968	4·25	10·058032	49
12	818681	2·40	876457	1·84	942223	4 25	057777	48
13	818825	2·40	876347	1·84	942478	4·25	057522	47
14	818969	2·40	876236	1·85	942733	4·25	057267	46
15	819113	2·40	876125	1·85	942988	4·25	057012	45
16	819257	2·40	876014	1·85	943243	4·25	056757	44
17	819401	2·40	875904	1·85	943498	4·25	056502	43
18	819545	2·39	875793	1·85	943752	4·25	056248	42
19	819689	2·39	875682	1·85	944007	4·25	055993	41
20	819832	2·39	875571	1·85	944262	4·25	055738	40
21	9·819976	2·39	9·875459	1·85	9·944517	4·25	10·055483	39
22	820120	2·39	875348	1·85	944771	4·24	055229	38
23	820263	2·39	875237	1·85	945026	4·24	054974	37
24	820406	2·39	875126	1·86	945281	4·24	054719	36
25	820550	2·38	875014	1·86	945535	4·24	054465	35
26	820693	2·38	874903	1·86	945790	4·24	054210	34
27	820836	2·38	874791	1·86	946045	4·24	053955	33
28	820979	2·38	874680	1·86	946299	4·24	053701	32
29	821122	2·38	874568	1·86	946554	4·24	053446	31
30	821265	2·38	874456	1·86	946808	4·24	053192	30
31	9·821407	2·38	9·874344	1·86	9·947063	4·24	10·052937	29
32	821550	2·38	874232	1·87	947318	4·24	052682	28
33	821693	2·37	874121	1·87	947572	4·24	052428	27
34	821835	2·37	874009	1·87	947826	4·24	052174	26
35	821977	2·37	873896	1·87	948081	4·24	051919	25
36	822120	2·37	873784	1·87	948336	4·24	051664	24
37	822262	2·37	873672	1·87	948590	4·24	051410	23
38	822404	2·37	873560	1·87	948844	4·24	051156	22
39	822546	2·37	873448	1·87	949099	4·24	050901	21
40	822688	2·36	873335	1·87	949353	4·24	050647	20
41	9·822830	2·36	9·873223	1·87	9·949607	4·24	10·050393	19
42	822972	2·36	873110	1·88	949862	4·24	050138	18
43	823114	2·36	872998	1·88	950116	4·24	049884	17
44	823255	2·36	872885	1·88	950370	4·24	049630	16
45	823397	2·36	872772	1·88	950625	4·24	049375	15
46	823539	2·36	872659	1·88	950879	4·24	049121	14
47	823680	2·35	872547	1·88	951133	4·24	048867	13
48	823821	2·35	872434	1·88	951388	4·24	048612	12
49	823963	2·35	872321	1·88	951642	4·24	048358	11
50	824104	2·35	872208	1·88	951896	4·24	048104	10
51	9·824245	2·35	9·872095	1·89	9·952150	4·24	10·047850	9
52	824386	2·35	871981	1·89	952405	4·24	047595	8
53	824527	2·35	871868	1·89	952659	4·24	047341	7
54	824668	2·34	871755	1·89	952913	4·24	047087	6
55	824808	2·34	871641	1·89	953167	4·23	046833	5
56	824949	2·34	871528	1·89	953421	4·23	046579	4
57	825090	2·34	871414	1·89	953675	4·23	046325	3
58	825230	2·34	871301	1·89	953929	4·23	046071	2
59	825371	2·34	871187	1·89	954183	4·23	045817	1
60	825511	2·34	871073	1·90	954437	4·23	045563	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(48 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·825511	2·34	9·871073	1·90	9·954437	4·23	10·045563	60
1	825651	2·33	870960	1·90	954691	4·23	045309	59
2	825791	2·33	870846	1·90	954945	4·23	045055	58
3	825931	2·33	870732	1·90	955200	4·23	044800	57
4	826071	2·33	870618	1·90	955454	4·23	044546	56
5	826211	2·33	870504	1·90	955707	4·23	044293	55
6	826351	2·33	870390	1·90	955961	4·23	044039	54
7	826491	2·33	870276	1·90	956215	4·23	043785	53
8	826631	2·33	870161	1·90	956469	4·23	043531	52
9	826770	2·32	870047	1·91	956723	4·23	043277	51
10	826910	2·32	869933	1·91	956977	4·23	043023	50
11	9·827049	2·32	9·869818	1·91	9·957231	4·23	10·042769	49
12	827189	2·32	869704	1·91	957485	4·23	042515	48
13	827328	2·32	869589	1·91	957739	4·23	042261	47
14	827467	2·32	869474	1·91	957993	4·23	042007	46
15	827606	2·32	869360	1·91	958246	4·23	041754	45
16	827745	2·32	869245	1·91	958500	4·23	041500	44
17	827884	2·31	869130	1·91	958754	4·23	041246	43
18	828023	2·31	869015	1·92	959008	4·23	040992	42
19	828162	2·31	868900	1·92	959262	4·23	040738	41
20	828301	2·31	868785	1·92	959516	4·23	040484	40
21	9·828439	2·31	9·868670	1·92	9·959769	4·23	10·040231	39
22	828578	2·31	868555	1·92	960023	4·23	039977	38
23	828716	2·31	868440	1·92	960277	4·23	039723	37
24	828855	2·30	868324	1·92	960531	4·23	039469	36
25	828993	2·30	868209	1·92	960784	4·23	039216	35
26	829131	2·30	868093	1·92	961038	4·23	038962	34
27	829269	2·30	867978	1·93	961291	4·23	038709	33
28	829407	2·30	867862	1·93	961545	4·23	038455	32
29	829545	2·30	867747	1·93	961799	4·23	038201	31
30	829683	2·30	867631	1·93	962052	4·23	037948	30
31	9·829821	2·29	9·867515	1·93	9·962306	4·23	10·037694	29
32	829959	2·29	867399	1·93	962560	4·23	037440	28
33	830097	2·29	867283	1·93	962813	4·23	037187	27
34	830234	2·29	867167	1·93	963067	4·23	036933	26
35	830372	2·29	867051	1·93	963320	4·23	036680	25
36	830509	2·29	866935	1·94	963574	4·23	036426	24
37	830646	2·29	866819	1·94	963827	4·23	036173	23
38	830784	2·29	866703	1·94	964081	4·23	035919	22
39	830921	2·28	866586	1·94	964335	4·23	035665	21
40	831058	2·28	866470	1·94	964588	4·22	035412	20
41	9·831195	2·28	9·866353	1·94	9·964842	4·22	10·035158	19
42	831332	2·28	866237	1·94	965095	4·22	034905	18
43	831469	2·28	866120	1·94	965349	4·22	034651	17
44	831606	2·28	866004	1·95	965602	4·22	034398	16
45	831742	2·28	865887	1·95	965855	4·22	034145	15
46	831879	2·28	865770	1·95	966105	4·22	033891	14
47	832015	2·27	865653	1·95	966362	4·22	033638	13
48	832152	2·27	865536	1·95	966616	4·22	033384	12
49	832288	2·27	865419	1·95	966869	4·22	033131	11
50	832425	2·27	865302	1·95	967123	4·22	032877	10
51	9·832561	2·27	9·865185	1·95	9·967376	4·22	10·032624	9
52	832697	2·27	865068	1·95	967629	4·22	032371	8
53	832833	2·27	864950	1·95	967883	4·22	032117	7
54	832969	2·26	864833	1·96	968136	4·22	031864	6
55	833105	2·26	864716	1·96	968389	4·22	031611	5
56	833241	2·26	864598	1·96	968643	4·22	031357	4
57	833377	2·26	864481	1·96	968896	4·22	031104	3
58	833512	2·26	864363	1·96	969149	4·22	030851	2
59	833648	2·26	864245	1·96	969403	4·22	030597	1
60	833783	2·26	864127	1·96	969656	4·22	030344	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(47 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·833783	2·26	9·864127	1·96	9·969656	4·22	10·030344	60
1	833919	2·25	864010	1·96	969909	4·22	030091	59
2	834054	2·25	863892	1·97	970162	4·22	029838	58
3	834189	2·25	863774	1·97	970416	4·22	029584	57
4	834325	2·25	863656	1·97	970669	4·22	029331	56
5	834460	2·25	863538	1·97	970922	4·22	029078	55
6	834595	2·25	863419	1·97	971175	4·22	028825	54
7	834730	2·25	863301	1·97	971429	4·22	028571	53
8	834865	2·25	863183	1·97	971682	4·22	028318	52
9	834999	2·24	863064	1·97	971935	4·22	028065	51
10	835134	2·24	862946	1·98	972188	4·22	027812	50
11	9·835269	2·24	9·862827	1·98	9·972441	4·22	10·027559	49
12	835403	2·24	862709	1·98	972694	4·22	027306	48
13	835538	2·24	862590	1·98	972948	4·22	027052	47
14	835672	2·24	862471	1·98	973201	4·22	026799	46
15	835807	2·24	862353	1·98	973454	4·22	026546	45
16	835941	2·24	862234	1·98	973707	4·22	026293	44
17	836075	2·23	862115	1·98	973960	4·22	026040	43
18	836209	2·23	861996	1·98	974213	4·22	025787	42
19	836343	2·23	861877	1·98	974466	4·22	025534	41
20	836477	2·23	861758	1·99	974719	4·22	025281	40
21	9·836611	2·23	9·861638	1·99	9·974973	4·22	10·025027	39
22	836745	2·23	861519	1·99	975226	4·22	024774	38
23	836878	2·23	861400	1·99	975479	4·22	024521	37
24	837012	2·22	861280	1·99	975732	4·22	024268	36
25	837146	2·22	861161	1·99	975985	4·22	024015	35
26	837279	2·22	861041	1·99	976238	4·22	023762	34
27	837412	2·22	860922	1·99	976491	4·22	023509	33
28	837546	2·22	860802	1·99	976744	4·22	023256	32
29	837679	2·22	860682	2·00	976997	4·22	023003	31
30	837812	2·22	860562	2·00	977250	4·22	022750	30
31	9·837945	2·22	9·860442	2·00	9·977503	4·22	10·022497	29
32	838078	2·21	860322	2·00	977756	4·22	022244	28
33	838211	2·21	860202	2·00	978009	4·22	021991	27
34	838344	2·21	860082	2·00	978262	4·22	021738	26
35	838477	2·21	859962	2·00	978515	4·22	021485	25
36	838610	2·21	859842	2·00	978768	4·22	021232	24
37	838742	2·21	859721	2·01	979021	4·22	020979	23
38	838875	2·21	859601	2·01	979274	4·22	020726	22
39	839007	2·21	859480	2·01	979527	4·22	020473	21
40	839140	2·20	859360	2·01	979780	4·22	020220	20
41	9·839272	2·20	9·859239	2·01	9·980033	4·22	10·019967	19
42	839404	2·20	859119	2·01	980286	4·22	019714	18
43	839536	2·20	858998	2·01	980538	4·22	019462	17
44	839668	2·20	858877	2·01	980791	4·21	019209	16
45	839800	2·20	858756	2·02	981044	4·21	018956	15
46	839932	2·20	858635	2·02	981297	4·21	018703	14
47	840064	2·19	858514	2·02	981550	4·21	018450	13
48	840196	2·19	858393	2·02	981803	4·21	018197	12
49	840328	2·19	858272	2·02	982056	4·21	017944	11
50	840459	2·19	858151	2·02	982309	4·21	017691	10
51	9·840591	2·19	9·858029	2·02	9·982562	4·21	10·017438	9
52	840722	2·19	857908	2·02	982814	4·21	017186	8
53	840854	2·19	857786	2·02	983067	4·21	016933	7
54	840985	2·19	857665	2·03	983320	4·21	016680	6
55	841116	2·18	857543	2·03	983573	4·21	016427	5
56	841247	2·18	857422	2·03	983826	4·21	016174	4
57	841378	2·18	857300	2·03	984079	4·21	015921	3
58	841509	2·18	857178	2·03	984331	4·21	015669	2
59	841640	2·18	857056	2·03	984584	4·21	015416	1
60	841771	2·18	856934	2·03	984837	4·21	015163	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(46 DEGREES.)

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9·841771	2·18	9·856934	2·03	9·984837	4·21	10·015163	60
1	841902	2·18	856812	2·03	985090	4·21	014910	59
2	842033	2·18	856690	2·04	985343	4·21	014657	58
3	842163	2·17	856568	2·04	985596	4·21	014404	57
4	842294	2·17	856446	2·04	985848	4·21	014152	56
5	842424	2·17	856323	2·04	986101	4·21	013899	55
6	842555	2·17	856201	2·04	986354	4·21	013646	54
7	842685	2·17	856078	2·04	986607	4·21	013393	53
8	842815	2·17	855956	2·04	986860	4·21	013140	52
9	842946	2·17	855833	2·04	987112	4·21	012888	51
10	843076	2·17	855711	2·05	987365	4·21	012635	50
11	9·843206	2·16	9·855588	2·05	9·987618	4·21	10·012382	49
12	843336	2·16	855465	2·05	987871	4·21	012129	48
13	843466	2·16	855342	2·05	988123	4·21	011877	47
14	843595	2·16	855219	2·05	988376	4·21	011624	46
15	843725	2·16	855096	2·05	988629	4·21	011371	45
16	843855	2·16	854973	2·05	988882	4·21	011118	44
17	843984	2·16	854850	2·05	989134	4·21	010866	43
18	844114	2·15	854727	2·06	989387	4·21	010613	42
19	844243	2·15	854603	2·06	989640	4·21	010360	41
20	844372	2·15	854480	2·06	989893	4·21	010107	40
21	9·844502	2·15	9·854356	2·06	9·990145	4·21	10·009855	39
22	844631	2·15	854233	2·06	990398	4·21	009602	38
23	844760	2·15	854109	2·06	990651	4·21	009349	37
24	844889	2·15	853986	2·06	990903	4·21	009097	36
25	845018	2·15	853862	2·06	991156	4·21	008844	35
26	845147	2·15	853738	2·06	991409	4·21	008591	34
27	845276	2·14	853614	2·07	991662	4·21	008338	33
28	845405	2·14	853490	2·07	991914	4·21	008086	32
29	845533	2·14	853366	2·07	992167	4·21	007833	31
30	845662	2·14	853242	2·07	992420	4·21	007580	30
31	9·845790	2·14	9·853118	2·07	9·992672	4·21	10·007328	29
32	845919	2·14	852994	2·07	992925	4·21	007075	28
33	846047	2·14	852869	2·07	993178	4·21	006822	27
34	846175	2·14	852745	2·07	993430	4·21	006570	26
35	846304	2·14	852620	2·07	993683	4·21	006317	25
36	846432	2·13	852496	2·08	993936	4·21	006064	24
37	846560	2·13	852371	2·08	994189	4·21	005811	23
38	846688	2·13	852247	2·08	994441	4·21	005559	22
39	846816	2·13	852122	2·08	994694	4·21	005306	21
40	846944	2·13	851997	2·08	994947	4·21	005053	20
41	9·847071	2·13	9·851872	2·08	9·995199	4·21	10·004801	19
42	847199	2·13	851747	2·08	995452	4·21	004548	18
43	847327	2·13	851622	2·08	995705	4·21	004295	17
44	847454	2·12	851497	2·09	995957	4·21	004043	16
45	847582	2·12	851372	2·09	996210	4·21	003790	15
46	847709	2·12	851246	2·09	996463	4·21	003537	14
47	847836	2·12	851121	2·09	996715	4·21	003285	13
48	847964	2·12	850996	2·09	996968	4·21	003032	12
49	848091	2·12	850870	2·09	997221	4·21	002779	11
50	848218	2·12	850745	2·09	997473	4·21	002527	10
51	9·848345	2·12	9·850619	2·09	9·997726	4·21	10·002274	9
52	848472	2·11	850493	2·10	997979	4·21	002021	8
53	848599	2·11	850368	2·10	998231	4·21	001769	7
54	848726	2·11	850242	2·10	998484	4·21	001516	6
55	848852	2·11	850116	2·10	998737	4·21	001263	5
56	848979	2·11	849990	2·10	998989	4·21	001011	4
57	849106	2·11	849864	2·10	999242	4·21	000758	3
58	849232	2·11	849738	2·10	999495	4·21	000505	2
59	849359	2·11	849611	2·10	999748	4·21	000253	1
60	849485	2·11	849485	2·10	10·000000	4·21	10·000000	0
	Cosine	D.	Sine	D.	Cotang.	D.	Tang.	M.

(45 DEGREES.)

	0 Deg.		1 Deg.		2 Deg.		3 Deg.		4 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	M
0	00000	Unit.	01745	99985	03490	99939	05234	99863	06976	99756	60
1	00029	1·0000	01774	99984	03519	99938	05263	99861	07005	99754	59
2	00058	1·0000	01803	99984	03548	99937	05292	99860	07034	99752	58
3	00087	1·0000	01832	99983	03577	99936	05321	99858	07063	99750	57
4	00116	1·0000	01862	99983	03606	99935	05350	99857	07092	99748	56
5	00145	1·0000	01891	99982	03635	99934	05379	99855	07121	99746	55
6	00175	1·0000	01920	99982	03664	99933	05408	99854	07150	99744	54
7	00204	1·0000	01949	99981	03693	99932	05437	99852	07179	99742	53
8	00233	1·0000	01978	99980	03723	99931	05466	99851	07208	99740	52
9	00262	1·0000	02007	99980	03752	99930	05495	99849	07237	99738	51
10	00291	1·0000	02036	99979	03781	99929	05524	99847	07266	99736	50
11	00320	99999	02065	99979	03810	99927	05553	99846	07295	99734	49
12	00349	99999	02094	99978	03839	99926	05582	99844	07324	99731	48
13	00378	99999	02123	99977	03868	99925	05611	99842	07353	99729	47
14	00407	99999	02152	99977	03897	99924	05640	99841	07382	99727	46
15	00436	99999	02181	99976	03926	99923	05669	99839	07411	99725	45
16	00465	99999	02211	99976	03955	99922	05698	99838	07440	99723	44
17	00495	99999	02240	99975	03984	99921	05727	99836	07469	99721	43
18	00524	99999	02269	99974	04013	99919	05756	99834	07498	99719	42
19	00553	99998	02298	99974	04042	99918	05785	99833	07527	99716	41
20	00582	99998	02327	99973	04071	99917	05814	99831	07556	99714	40
21	00611	99998	02356	99972	04100	99916	05844	99829	07585	99712	39
22	00640	99998	02385	99972	04129	99915	05873	99827	07614	99710	38
23	00669	99998	02414	99971	04159	99913	05902	99826	07643	99708	37
24	00698	99998	02443	99970	04188	99912	05931	99824	07672	99705	36
25	00727	99997	02472	99969	04217	99911	05960	99822	07701	99703	35
26	00756	99997	02501	99969	04246	99910	05989	99821	07730	99701	34
27	00785	99997	02530	99968	04275	99909	06018	99819	07759	99699	33
28	00814	99997	02560	99967	04304	99907	06047	99817	07788	99696	32
29	00844	99996	02589	99966	04333	99906	06076	99815	07817	99694	31
30	00873	99996	02618	99966	04362	99905	06105	99813	07846	99692	30
31	00902	99996	02647	99965	04391	99904	06134	99812	07875	99689	29
32	00931	99996	02676	99964	04420	99902	06163	99810	07904	99687	28
33	00960	99995	02705	99963	04449	99901	06192	99808	07933	99685	27
34	00989	99995	02734	99963	04478	99900	06221	99806	07962	99683	26
35	01018	99995	02763	99962	04507	99898	06250	99804	07991	99680	25
36	01047	99995	02792	99961	04536	99897	06279	99803	08020	99678	24
37	01076	99994	02821	99960	04565	99896	06308	99801	08049	99676	23
38	01105	99994	02850	99959	04594	99894	06337	99799	08078	99673	22
39	01134	99994	02879	99959	04623	99893	06366	99797	08107	99671	21
40	01164	99993	02008	99958	04653	99892	06395	99795	08136	99668	20
41	01193	99993	02938	99957	04682	99890	06424	99793	08165	99666	19
42	01222	99993	02967	99956	04711	99889	06453	99792	08194	99664	18
43	01251	99992	02996	99955	04740	99888	06482	99790	08223	99661	17
44	01280	99992	03025	99954	04769	99886	06511	99788	08252	99659	16
45	01309	99991	03054	99953	04798	99885	06540	99786	08281	99657	15
46	01338	99991	03083	99952	04827	99883	06569	99784	08310	99654	14
47	01367	99991	03112	99952	04856	99882	06598	99782	08339	99652	13
48	01396	99990	03141	99951	04885	99881	06627	99780	08368	99649	12
49	01425	99990	03170	99950	04914	99879	06656	99778	08397	99647	11
50	01454	99989	03199	99949	04943	99878	06685	99776	08426	99644	10
51	01483	99989	03228	99948	04972	99876	06714	99774	08455	99642	9
52	01513	99989	03257	99947	05001	99875	06743	99772	08484	99639	8
53	01542	99988	03286	99946	05030	99873	06773	99770	08513	99637	7
54	01571	99988	03316	99945	05059	99872	06802	99768	08542	99635	6
55	01600	99987	03345	99944	05088	99870	06831	99766	08571	99632	5
56	01629	99987	03374	99943	05117	99869	06860	99764	08600	99630	4
57	01658	99986	03403	99942	05146	99867	06889	99762	08629	99627	3
58	01687	99986	03432	99941	05175	99866	06918	99760	08658	99625	2
59	01716	99985	03461	99940	05205	99864	06947	99758	08687	99622	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	89 Deg.		88 Deg.		87 Deg.		86 Deg.		85 Deg.		

	5 Deg.		6 Deg.		7 Deg.		8 Deg.		9 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S	S.	C S.	M
0	08716	99619	10453	99452	12187	99255	13917	99027	15643	98769	60
1	08745	99617	10482	99449	12216	99251	13946	99023	15672	98764	59
2	08774	99614	10511	99446	12245	99248	13975	99019	15701	98760	58
3	08803	99612	10540	99443	12274	99244	14004	99015	15730	98755	57
4	08831	99609	10569	99440	12302	99240	14033	99011	15758	98751	56
5	08860	99607	10597	99437	12331	99237	14061	99006	15787	98746	55
6	08889	99604	10626	99434	12360	99233	14090	99002	15816	98741	54
7	08918	99602	10655	99431	12389	99230	14119	98998	15845	98737	53
8	08947	99599	10684	99428	12418	99226	14148	98994	15873	98732	52
9	08976	99596	10713	99424	12447	99222	14177	98990	15902	98728	51
10	09005	99594	10742	99421	12476	99219	14205	98986	15931	98723	50
11	09034	99591	10771	99418	12504	99215	14234	98982	15959	98718	49
12	09063	99588	10800	99415	12533	99211	14263	98978	15988	98714	48
13	09092	99586	10829	99412	12562	99208	14292	98973	16017	98709	47
14	09121	99583	10858	99409	12591	99204	14320	98969	16046	98704	46
15	09150	99580	10887	99406	12620	99200	14349	98965	16074	98700	45
16	09179	99578	10916	99402	12649	99197	14378	98961	16103	98695	44
17	09208	99575	10945	99399	12678	99193	14407	98957	16132	98690	43
18	09237	99572	10973	99396	12706	99189	14436	98953	16160	98686	42
19	09266	99570	11002	99393	12735	99186	14464	98948	16189	98681	41
20	09295	99567	11031	99390	12764	99182	14493	98944	16218	98676	40
21	09324	99564	11060	99386	12793	99178	14522	98940	16246	98671	39
22	09353	99562	11089	99383	12822	99175	14551	98936	16275	98667	38
23	09382	99559	11118	99380	12851	99171	14580	98931	16304	98662	37
24	09411	99556	11147	99377	12880	99167	14608	98927	16333	98657	36
25	09440	99553	11176	99374	12908	99163	14637	98923	16361	98652	35
26	09469	99551	11205	99370	12937	99160	14666	98919	16390	98648	34
27	09498	99548	11234	99367	12966	99156	14695	98914	16419	98643	33
28	09527	99545	11263	99364	12995	99152	14723	98910	16447	98638	32
29	09556	99542	11291	99360	13024	99148	14752	98906	16476	98633	31
30	09585	99540	11320	99357	13053	99144	14781	98902	16505	98629	30
31	09614	99537	11349	99354	13081	99141	14810	98897	16533	98624	29
32	09642	99534	11378	99351	13110	99137	14838	98893	16562	98619	28
33	09671	99531	11407	99347	13139	99133	14867	98889	16591	98614	27
34	09700	99528	11436	99344	13168	99129	14896	98884	16620	98609	26
35	09729	99526	11465	99341	13197	99125	14925	98880	16648	98604	25
36	09758	99523	11494	99337	13226	99122	14954	98876	16677	98600	24
37	09787	99520	11523	99334	13254	99118	14982	98871	16706	98595	23
38	09816	99517	11552	99331	13283	99114	15011	98867	16734	98590	22
39	09845	99514	11580	99327	13312	99110	15040	98863	16763	98585	21
40	09874	99511	11609	99324	13341	99106	15069	98858	16792	98580	20
41	09903	99508	11638	99320	13370	99102	15097	98854	16820	98575	19
42	09932	99506	11667	99317	13399	99098	15126	98849	16849	98570	18
43	09961	99503	11696	99314	13427	99094	15155	98845	16878	98565	17
44	09990	99500	11725	99310	13456	99091	15184	98841	16906	98561	16
45	10019	99497	11754	99307	13485	99087	15212	98836	16935	98556	15
46	10048	99494	11783	99303	13514	99083	15241	98832	16964	98551	14
47	10077	99491	11812	99300	13543	99079	15270	98827	16992	98546	13
48	10106	99488	11840	99297	13572	99075	15292	98823	17021	98541	12
49	10135	99485	11869	99293	13600	99071	15327	98818	17050	98536	11
50	10164	99482	11898	99290	13629	99067	15356	98814	17078	98531	10
51	10192	99479	11927	99286	13658	99063	15385	98809	17107	98526	9
52	10221	99476	11956	99283	13687	99059	15414	98805	17136	98521	8
53	10250	99473	11985	99279	13716	99055	15442	98800	17164	98516	7
54	10279	99470	12014	99276	13744	99051	15471	98796	17193	98511	6
55	10308	99467	12043	99272	13773	99047	15500	98791	17222	98506	5
56	10337	99464	12071	99269	13802	99043	15529	98787	17250	98501	4
57	10366	99461	12100	99265	13831	99039	15557	98782	17279	98496	3
58	10395	99458	12129	99262	13860	99035	15586	98778	17308	98491	2
59	10424	99455	12158	99258	13889	99031	15615	98773	17336	98486	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	84 Deg.		83 Deg.		82 Deg.		81 Deg		80 Deg		

M	10 Deg.		11 Deg.		12 Deg.		13 Deg.		14 Deg.		
	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	M
0	17365	98481	19081	98163	20791	97815	22495	97437	24192	97030	60
1	17393	98476	19109	98157	20820	97809	22523	97430	24220	97023	59
2	17422	98471	19138	98152	20848	97803	22552	97424	24249	97015	58
3	17451	98466	19167	98146	20877	97797	22580	97417	24277	97008	57
4	17479	98461	19195	98140	20905	97791	22608	97411	24305	97001	56
5	17508	98455	19224	98135	20933	97784	22637	97404	24333	96994	55
6	17537	98450	19252	98129	20962	97778	22665	97398	24362	96987	54
7	17565	98445	19281	98124	20990	97772	22693	97391	24390	96980	53
8	17594	98440	19309	98118	21019	97766	22722	97384	24418	96973	52
9	17623	98435	19338	98112	21047	97760	22750	97378	24446	96966	51
10	17651	98430	19366	98107	21076	97754	22778	97371	24474	96959	50
11	17680	98425	19395	98101	21104	97748	22807	97365	24503	96952	49
12	17708	98420	19423	98096	21132	97742	22835	97358	24531	96945	48
13	17737	98414	19452	98090	21161	97735	22863	97351	24559	96937	47
14	17766	98409	19481	98084	21189	97729	22892	97345	24587	96930	46
15	17794	98404	19509	98079	21218	97723	22920	97338	24615	96923	45
16	17823	98399	19538	98073	21246	97717	22948	97331	24644	96916	44
17	17852	98394	19566	98067	21275	97711	22977	97325	24672	96909	43
18	17880	98389	19595	98061	21303	97705	23005	97318	24700	96902	42
19	17909	98383	19623	98056	21331	97698	23033	97311	24728	96894	41
20	17937	98378	19652	98050	21360	97692	23062	97304	24756	96887	40
21	17966	98373	19680	98044	21388	97686	23090	97298	24784	96880	39
22	17995	98368	19709	98039	21417	97680	23118	97291	24813	96873	38
23	18023	98362	19737	98033	21445	97673	23146	97284	24841	96866	37
24	18052	98357	19766	98027	21474	97667	23175	97278	24869	96858	36
25	18081	98352	19794	98021	21502	97661	23203	97271	24897	96851	35
26	18109	98347	19823	98016	21530	97655	23231	97264	24925	96844	34
27	18138	98341	19851	98010	21559	97648	23260	97257	24953	96837	33
28	18166	98336	19880	98004	21587	97642	23288	97251	24982	96829	32
29	18195	98331	19908	97998	21616	97636	23316	97244	25010	96822	31
30	18224	98325	19937	97992	21644	97630	23345	97237	25038	96815	30
31	18252	98320	19965	97987	21672	97623	23373	97230	25066	96807	29
32	18281	98315	19994	97981	21701	97617	23401	97223	25094	96800	28
33	18309	98310	20022	97975	21729	97611	23429	97217	25122	96793	27
34	18338	98304	20051	97969	21758	97604	23458	97210	25151	96786	26
35	18367	98299	20079	97963	21786	97598	23486	97203	25179	96778	25
36	18395	98294	20108	97958	21814	97592	23514	97196	25207	96771	24
37	18424	98288	20136	97952	21843	97585	23542	97189	25235	96764	23
38	18452	98283	20165	97946	21871	97579	23571	97182	25263	96756	22
39	18481	98277	20193	97940	21899	97573	23599	97176	25291	96749	21
30	18509	98272	20222	97934	21928	97566	23627	97169	25320	96742	20
41	18538	98267	20250	97928	21956	97560	23656	97162	25348	96734	19
42	18567	98261	20279	97922	21985	97553	23684	97155	25376	96727	18
43	18595	98256	20307	97916	22013	97547	23712	97148	25404	96719	17
44	18624	98250	20336	97910	22041	97541	23740	97141	25432	96712	16
45	18652	98245	20364	97905	22070	97534	23769	97134	25460	96705	15
46	18681	98240	20393	97899	22098	97528	23797	97127	25488	96697	14
47	18710	98234	20421	97893	22126	97521	23825	97120	25516	96690	13
48	18738	98229	20450	97887	22155	97515	23853	97113	25545	96682	12
49	18767	98223	20478	97881	22183	97508	23882	97106	25573	96675	11
50	18795	98218	20507	97875	22212	97502	23910	97100	25601	96667	10
51	18824	98212	20535	97869	22240	97496	23938	97093	25629	96660	9
52	18852	98207	20563	97863	22268	97489	23966	97086	25657	96653	8
53	18881	98201	20592	97857	22297	97483	23995	97079	25685	96645	7
54	18910	98196	20620	97851	22325	97476	24023	97072	25713	96638	6
55	18938	98190	20649	97845	22353	97470	24051	97065	25741	96630	5
56	18967	98185	20677	97839	22382	97463	24079	97058	25769	96623	4
57	18995	98179	20706	97833	22410	97457	24108	97051	25798	96615	3
58	19024	98174	20734	97827	22438	97450	24136	97044	25826	96608	2
59	19052	98168	20763	97821	22467	97444	24164	97037	25854	96600	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	79 Deg.		78 Deg.		77 Deg.		76 Deg.		75 Deg.		

	15 Deg.		16 Deg.		17 Deg.		18 Deg.		19 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	S. C.	M
0	25882	96593	27564	96126	29237	95630	30902	95106	32557	94552	60
1	25910	96585	27592	96118	29265	95622	30929	95097	32584	94542	59
2	25938	96578	27620	96110	29293	95613	30957	95088	32612	94533	58
3	25966	96570	27648	96102	29321	95605	30985	95079	32639	94523	57
4	25994	96562	27676	96094	29348	95596	31012	95070	32667	94514	56
5	26022	96555	27704	96086	29376	95588	31040	95061	32694	94504	55
6	26050	96547	27731	96078	29404	95579	31068	95052	32722	94495	54
7	26079	96540	27759	96070	29432	95571	31095	95043	32749	94485	53
8	26107	96532	27787	96062	29460	95562	31123	95033	32777	94476	52
9	26135	96524	27815	96054	29487	95554	31151	95024	32804	94466	51
10	26163	96517	27843	96046	29515	95545	31178	95015	32832	94457	50
11	26191	96509	27871	96037	29543	95536	31206	95006	32859	94447	49
12	26219	96502	27899	96029	29571	95528	31233	94997	32887	94438	48
13	26247	96494	27927	96021	29599	95519	31261	94988	32914	94428	47
14	26275	96486	27955	96013	29626	95511	31289	94979	32942	94418	46
15	26303	96479	27983	96005	29654	95502	31316	94970	32969	94409	45
16	26331	96471	28011	95997	29682	95493	31344	94961	32997	94399	44
17	26359	96463	28039	95989	29710	95485	31372	94952	33024	94390	43
18	26387	96456	28067	95981	29737	95476	31399	94943	33051	94380	42
19	26415	96448	28095	95972	29765	95467	31427	94933	33079	94370	41
20	26443	96440	28123	95964	29793	95459	31454	94924	33106	94361	40
21	26471	96433	28150	95956	29821	95450	31482	94915	33134	94351	39
22	26500	96425	28178	95948	29849	95441	31510	94906	33161	94342	38
23	26528	96417	28206	95940	29876	95433	31537	94897	33189	94332	37
24	26556	96410	28234	95931	29904	95424	31565	94888	33216	94322	36
25	26584	96402	28262	95923	29932	95415	31593	94878	33244	94313	35
26	26612	96394	28290	95915	29960	95407	31620	94869	33271	94303	34
27	26640	96386	28318	95907	29987	95398	31648	94860	33298	94293	33
28	26668	96379	28346	95898	30015	95389	31675	94851	33326	94284	32
29	26696	96371	28374	95890	30043	95380	31703	94842	33353	94274	31
30	26724	96363	28402	95882	30071	95372	31730	94832	33381	94264	30
31	26752	96355	28429	95874	30098	95363	31758	94823	33408	94254	29
32	26780	96347	28457	95865	30126	95354	31786	94814	33436	94245	28
33	26808	96340	28485	95857	30154	95345	31813	94805	33463	94235	27
34	26836	96332	28513	95849	30182	95337	31841	94795	33490	94225	26
35	26864	96324	28541	95841	30209	95328	31868	94786	33518	94215	25
36	26892	96316	28569	95832	30237	95319	31896	94777	33545	94206	24
37	26920	96308	28597	95824	30265	95310	31923	94768	33573	94196	23
38	26948	96301	28625	95816	30292	95301	31951	94758	33600	94186	22
39	26976	96293	28652	95807	30320	95293	31979	94749	33627	94176	21
40	27004	96285	28680	95799	30348	95284	32006	94740	33655	94167	20
41	27032	96277	28708	95791	30376	95275	32034	94730	33682	94157	19
42	27060	96269	28736	95782	30403	95266	32061	94721	33710	94147	18
43	27088	96261	28764	95774	30431	95257	32089	94712	33737	94137	17
44	27116	96253	28792	95766	30459	95248	32116	94702	33764	94127	16
45	27144	96246	28820	95757	30486	95240	32144	94693	33792	94118	15
46	27172	96238	28847	95749	30514	95231	32171	94684	33819	94108	14
47	27200	96230	28875	95740	30542	95222	32199	94674	33846	94098	13
48	27228	96222	28903	95732	30570	95213	32227	94665	33874	94088	12
49	27256	96214	28931	95724	30597	95204	32254	94656	33901	94078	11
50	27284	96206	28959	95715	30625	95195	32282	94646	33929	94068	10
51	27312	96198	28987	95707	30653	95186	32309	94637	33956	94058	9
52	27340	96190	29015	95698	30680	95177	32337	94627	33983	94049	8
53	27368	96182	29042	95690	30708	95168	32364	94618	34011	94039	7
54	27396	96174	29070	95681	30736	95159	32392	94609	34038	94029	6
55	27424	96166	29098	95673	30763	95150	32419	94599	34065	94019	5
56	27452	96158	29126	95664	30791	95142	32447	94590	34093	94009	4
57	27480	96150	29154	95656	30819	95133	32474	94580	34120	93999	3
58	27508	96142	29182	95647	30846	95124	32502	94571	34147	93989	2
59	27536	96134	29209	95639	30874	95115	32529	94561	34175	93979	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	74 Deg.		78 Deg.		72 Deg.		71 Deg.		70 Deg.		

	20 Deg.		21 Deg.		22 Deg.		23 Deg.		24 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	M
0	34202	93969	35837	93358	37461	92718	39073	92050	40674	91355	60
1	34229	93959	35864	93348	37488	92707	39100	92039	40700	91343	59
2	34257	93949	35891	93337	37515	92697	39127	92028	40727	91331	58
3	34284	93939	35918	93327	37542	92686	39153	92016	40753	91319	57
4	34311	93929	35945	93316	37569	92675	39180	92005	40780	91307	56
5	34339	93919	35973	93306	37595	92664	39207	91994	40806	91295	55
6	34366	93909	36000	93295	37022	92053	39234	91982	40833	91283	54
7	34393	93899	36027	93285	37649	92642	39260	91971	40860	91272	53
8	34421	93889	36054	93274	37676	92631	39287	91959	40886	91260	52
9	34448	93879	36081	93264	37703	92620	39314	91948	40913	91248	51
10	34475	93869	36108	93253	37730	92609	39341	91936	40939	91236	50
11	34503	93859	36135	93243	37757	92598	39367	91925	40966	91224	49
12	34530	93849	36162	93232	37784	92587	39394	91914	40992	91212	48
13	34557	93839	36190	93222	37811	92576	39421	91902	41019	91200	47
14	34584	93829	36217	93211	37838	92565	39448	91891	41045	91188	46
15	34612	93819	36244	93201	37865	92554	39474	91879	41072	91176	45
16	34639	93809	36271	93190	37892	92543	39501	91868	41098	91164	44
17	34666	93799	36298	93180	37919	92532	39528	91856	41125	91152	43
18	34694	93789	36325	93169	37946	92521	39555	91845	41151	91140	42
19	34721	93779	36352	93159	37973	92510	39581	91833	41178	91128	41
20	34748	93769	36379	93148	37999	92499	39608	91822	41204	91116	40
21	34775	93759	36406	93137	38026	92488	39635	91810	41231	91104	39
22	34803	93748	36434	93127	38053	92477	39661	91799	41257	91092	38
23	34830	93738	36461	93116	38080	92466	39688	91787	41284	91080	37
24	34857	93728	36488	93106	38107	92455	39715	91775	41310	91068	36
25	34884	93718	36515	93095	38134	92444	39741	91764	41337	91056	35
26	34912	93708	36542	93084	38161	92432	39768	91752	41363	91044	34
27	34939	93698	36569	93074	38188	92421	39795	91741	41390	91032	33
28	34966	93688	36596	93063	38215	92410	39822	91729	41416	91020	32
29	34993	93677	36623	93052	38241	92399	39848	91718	41443	91008	31
30	35021	93667	36650	93042	38268	92388	39875	91706	41469	90996	30
31	35048	93657	36677	93031	38295	92377	39902	91694	41496	90984	29
32	35075	93647	36704	93020	38322	92366	39928	91683	41522	90972	28
33	35102	93637	36731	93010	38349	92355	39955	91671	41549	90960	27
34	35130	93626	36758	92999	38376	92343	39982	91660	41575	90948	26
35	35157	93616	36785	92988	38403	92332	40008	91648	41602	90936	25
36	35183	93606	36812	92978	38430	92321	40035	91636	41628	90924	24
37	35211	93596	36839	92967	38456	92310	40062	91625	41655	90911	23
38	35239	93585	36867	92956	38483	92299	40088	91613	41681	90899	22
39	35266	93575	36894	92945	38510	92287	40115	91601	41707	90887	21
40	35293	93565	36921	92935	38537	92276	40141	91590	41734	90875	20
41	35320	93555	36948	92924	38564	92265	40168	91578	41760	90863	19
42	35347	93544	36975	92913	38591	92254	40195	91566	41787	90851	18
43	35375	93534	37002	92902	38617	92243	40221	91555	41813	90839	17
44	35402	93524	37029	92892	38644	92231	40248	91543	41840	90826	16
45	35429	93514	37056	92881	38671	92220	40275	91531	41866	90814	15
46	35456	93503	37083	92870	38698	92209	40301	91519	41892	90802	14
47	35484	93493	37110	92859	38725	92198	40328	91508	41919	90790	13
48	35511	93483	37137	92849	38752	92186	40355	91496	41945	90778	12
49	35538	93472	37164	92838	38778	92175	40381	91484	41972	90766	11
50	35565	93462	37191	92827	38805	92164	40408	91472	41998	90753	10
51	35592	93452	37218	92816	38832	92152	40434	91461	42024	90741	9
52	35619	93441	37245	92805	38859	92141	40461	91449	42051	90729	8
53	35647	93431	37272	92794	38886	92130	40488	91437	42077	90717	7
54	35674	93420	37299	92784	38912	92119	40514	91425	42104	90704	6
55	35701	93410	37326	92773	38939	92107	40541	91414	42130	90692	5
56	35728	93400	37353	92762	38966	92096	40567	91402	42156	90680	4
57	35755	93389	37380	92751	38993	92085	40594	91390	42183	90668	3
58	35782	93379	37407	92740	39020	92073	40621	91378	42209	90655	2
59	35810	93368	37434	92729	39046	92062	40647	91366	42235	90643	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	69 Deg.		68 Deg.		67 Deg.		66 Deg.		65 Deg.		

	25 Deg.		26 Deg.		27 Deg.		28 Deg.		29 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	M
0	42262	90631	43837	89879	45399	89101	46947	88295	48481	87462	60
1	42288	90618	43863	89867	45425	89087	46973	88281	48506	87448	59
2	42315	90606	43889	89854	45451	89074	46999	88267	48532	87434	58
3	42341	90594	43916	89841	45477	89061	47024	88254	48557	87420	57
4	42367	90582	43942	89828	45503	89048	47050	88240	48583	87406	56
5	42394	90569	43968	89816	45529	89035	47076	88226	48608	87391	55
6	42420	90557	43994	89803	45554	89021	47101	88213	48634	87377	54
7	42446	90545	44020	89790	45580	89008	47127	88199	48659	87363	53
8	42473	90532	44046	89777	45606	88995	47153	88185	48684	87349	52
9	42499	90520	44072	89764	45632	88981	47178	88172	48710	87335	51
10	42525	90507	44098	89752	45658	88968	47204	88158	48735	87321	50
11	42552	90495	44124	89739	45684	88955	47229	88144	48761	87306	49
12	42578	90483	44151	89726	45710	88942	47255	88130	48786	87292	48
13	42604	90470	44177	89713	45736	88928	47281	88117	48811	87278	47
14	42631	90458	44203	89700	45762	88915	47306	88103	48837	87264	46
15	42657	90446	44229	89687	45787	88902	47332	88089	48862	87250	45
16	42683	90433	44255	89674	45813	88888	47358	88075	48888	87235	44
17	42709	90421	44281	89662	45839	88875	47383	88062	48913	87221	43
18	42736	90408	44307	89649	45865	88862	47409	88048	48938	87207	42
19	42762	90396	44333	89636	45891	88848	47434	88034	48964	87193	41
20	42788	90383	44359	89623	45917	88835	47460	88020	48989	87178	40
21	42815	90371	44385	89610	45942	88822	47486	88006	49014	87164	39
22	42841	90358	44411	89597	45968	88808	47511	87993	49040	87150	38
23	42867	90346	44437	89584	45994	88795	47537	87979	49065	87136	37
24	42894	90334	44464	89571	46020	88782	47562	87965	49090	87121	36
25	42920	90321	44490	89558	46046	88768	47588	87951	49116	87107	35
26	42946	90309	44516	89545	46072	88755	47614	87937	49141	87093	34
27	42972	90296	44542	89532	46097	88741	47639	87923	49166	87079	33
28	42999	90284	44568	89519	46123	88728	47665	87909	49192	87064	32
29	43025	90271	44594	89506	46149	88715	47690	87896	49217	87050	31
30	43051	90259	44620	89493	46175	88701	47716	87882	49242	87036	30
31	43077	90246	44646	89480	46201	88688	47741	87868	49268	87021	29
32	43104	90233	44672	89467	46226	88674	47767	87854	49293	87007	28
33	43130	90221	44698	89454	46252	88661	47793	87840	49318	86993	27
34	43156	90208	44724	89441	46278	88647	47818	87826	49344	86978	26
35	43182	90196	44750	89428	46304	88634	47844	87812	49369	86964	25
36	43209	90183	44776	89415	46330	88620	47869	87798	49394	86949	24
37	43235	90171	44802	89402	46355	88607	47895	87784	49419	86935	23
38	43261	90158	44828	89389	46381	88593	47920	87770	49445	86921	22
39	43287	90146	44854	89376	46407	88580	47946	87756	49470	86906	21
40	43313	90133	44880	89363	46433	88566	47971	87743	49495	86892	20
41	43340	90120	44906	89350	46458	88553	47997	87729	49521	86878	19
42	43366	90108	44932	89337	46484	88539	48022	87715	49546	86863	18
43	43392	90095	44958	89324	46510	88526	48048	87701	49571	86849	17
44	43418	90082	44984	89311	46536	88512	48073	87687	49596	86834	16
45	43445	90070	45010	89298	46561	88499	48099	87673	49622	86820	15
46	43471	90057	45036	89285	46587	88485	48124	87659	49647	86805	14
47	43497	90045	45062	89272	46613	88472	48150	87645	49672	86791	13
48	43523	90032	45088	89259	46639	88458	48175	87631	49697	86777	12
49	43549	90019	45114	89245	46664	88445	48201	87617	49723	86762	11
50	43575	90007	45140	89232	46690	88431	48226	87603	49748	86748	10
51	43602	89994	45166	89219	46716	88417	48252	87589	49773	86733	9
52	43628	89981	45192	89206	46742	88404	48277	87575	49798	86719	8
53	43654	89968	45218	89193	46767	88390	48303	87561	49824	86704	7
54	43680	89956	45243	89180	46793	88377	48328	87546	49849	86690	6
55	43706	89943	45269	89167	46819	88363	48354	87532	49874	86675	5
56	43733	89930	45295	89153	46844	88349	48379	87518	49899	86661	4
57	43759	89918	45321	89140	46870	88336	48405	87504	49924	86646	3
58	43785	89905	45347	89127	46896	88322	48430	87490	49950	86632	2
59	43811	89892	45373	89114	46921	88308	48456	87476	49975	86617	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	64 Deg.		63 Deg.		62 Deg.		61 Deg.		60 Deg.		

	30 Deg.		31 Deg.		32 Deg.		33 Deg.		34 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S	S.	C. S.	M
0	50000	86603	51504	85717	52992	84805	54464	83867	55919	82904	60
1	50025	86588	51529	85702	53017	84789	54488	83851	55943	82887	59
2	50050	86573	51554	85687	53041	84774	54513	83835	55968	82871	58
3	50076	86559	51579	85672	53066	84759	54537	83819	55992	82855	57
4	50101	86544	51604	85657	53091	84743	54561	83804	56016	82839	56
5	50126	86530	51628	85642	53115	84728	54586	83788	56040	82822	55
6	50151	86515	51653	85627	53140	84712	54610	83772	56064	82806	54
7	50176	86501	51678	85612	53164	84697	54635	83756	56088	82790	53
8	50201	86486	51703	85597	53189	84681	54659	83740	56112	82773	52
9	50227	86471	51728	85582	53214	84666	54683	83724	56136	82757	51
10	50252	86457	51753	85567	53238	84650	54708	83708	56160	82741	50
11	50277	86442	51778	85551	53263	84635	54732	83692	56184	82724	49
12	50302	86427	51803	85536	53288	84619	54756	83676	56208	82708	48
13	50327	86413	51828	85521	53312	84604	54781	83660	56232	82692	47
14	50352	86398	51852	85506	53337	84588	54805	83645	56256	82675	46
15	50377	86384	51877	85491	53361	84573	54829	83629	56280	82659	45
16	50403	86369	51902	85476	53386	84557	54854	83613	56305	82643	44
17	50428	86354	51927	85461	53411	84542	54878	83597	56329	82626	43
18	50453	86340	51952	85446	53435	84526	54902	83581	56353	82610	42
19	50478	86325	51977	85431	53460	84511	54927	83565	56377	82593	41
20	50503	86310	52002	85416	53484	84495	54951	83549	56401	82577	40
21	50528	86295	52026	85401	53509	84480	54975	83533	56425	82561	39
22	50553	86281	52051	85385	53534	84464	54999	83517	56449	82544	38
23	50578	86266	52076	85370	53558	84448	55024	83501	56473	82528	37
24	50603	86251	52101	85355	53583	84433	55048	83485	56497	82511	36
25	50628	86237	52126	85340	53607	84417	55072	83469	56521	82495	35
26	50654	86222	52151	85325	53632	84402	55097	83453	56545	82478	34
27	50679	86207	52175	85310	53656	84386	55121	83437	56569	82462	33
28	50704	86192	52200	85294	53681	84370	55145	83421	56593	82446	32
29	50729	86178	52225	85279	53705	84355	55169	83405	56617	82429	31
30	50754	86163	52250	85264	53730	84339	55194	83389	56641	82413	30
31	50779	86148	52275	85249	53754	84324	55218	83373	56665	82396	29
32	50804	86133	52299	85234	53779	84308	55242	83356	56689	82380	28
33	50829	86119	52324	85218	53804	84292	55266	83340	56713	82363	27
34	50854	86104	52349	85203	53828	84277	55291	83324	56736	82347	26
35	50879	86089	52374	85188	53853	84261	55315	83308	56760	82330	25
36	50904	86074	52399	85173	53877	84245	55339	83292	56784	82314	24
37	50929	86059	52423	85157	53902	84230	55363	83276	56808	82297	23
38	50954	86045	52448	85142	53926	84214	55388	83260	56832	82281	22
39	50979	86030	52473	85127	53951	84198	55412	83244	56856	82264	21
40	51004	86015	52498	85112	53975	84182	55436	83228	56880	82248	20
41	51029	86000	52522	85096	54000	84167	55460	83212	56904	82231	19
42	51054	85985	52547	85081	54024	84151	55484	83195	56928	82214	18
43	51079	85970	52572	85066	54049	84135	55509	83179	56952	82198	17
44	51104	85956	52597	85051	54073	84120	55533	83163	56976	82181	16
45	51129	85941	52621	85035	54097	84104	55557	83147	57000	82165	15
46	51154	85926	52646	85020	54122	84088	55581	83131	57024	82148	14
47	51179	85911	52671	85005	54146	84072	55605	83115	57047	82132	13
48	51204	85896	52696	84989	54171	84057	55630	83098	57071	82115	12
49	51229	85881	52720	84974	54195	84041	55654	83082	57095	82098	11
50	51254	85866	52745	84959	54220	84025	55678	83066	57119	82082	10
51	51279	85851	52770	84943	54244	84009	55702	83050	57143	82065	9
52	51304	85836	52794	84928	54269	83994	55726	83034	57167	82048	8
53	51329	85821	52819	84913	54293	83978	55750	83017	57191	82032	7
54	51354	85806	52844	84897	54317	83962	55775	83001	57215	82015	6
55	51379	85792	52869	84882	54342	83946	55799	82985	57238	81999	5
56	51404	85777	52893	84866	54366	83930	55823	82969	57262	81982	4
57	51429	85762	52918	84851	54391	83915	55847	82953	57286	81965	3
58	51454	85747	52943	84836	54415	83899	55871	82936	57310	81949	2
59	51479	85732	52967	84820	54440	83883	55895	82920	57334	81932	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	59 Deg.		58 Deg.		57 Deg.		56 Deg.		55 Deg.		

	35 Deg.		36 Deg.		37 Deg.		38 Deg.		39 Deg.		
M	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	M
0	57358	81915	58779	80902	60182	79864	61566	78801	62932	77715	60
1	57381	81899	58802	80885	60205	79846	61589	78783	62955	77696	59
2	57405	81882	58826	80867	60228	79829	61612	78765	62977	77678	58
3	57429	81865	58849	80850	60251	79811	61635	78747	63000	77660	57
4	57453	81848	58873	80833	60274	79793	61658	78729	63022	77641	56
5	57477	81832	58896	80816	60298	79776	61681	78711	63045	77623	55
6	57501	81815	58920	80799	60321	79758	61704	78694	63068	77605	54
7	57524	81798	58943	80782	60344	79741	61726	78676	63090	77586	53
8	57548	81782	58967	80765	60367	79723	61749	78658	63113	77568	52
9	57572	81765	58990	80748	60390	79706	61772	78640	63135	77550	51
10	57596	81748	59014	80730	60414	79688	61795	78622	63158	77531	50
11	57619	81731	59037	80713	60437	79671	61818	78604	63180	77513	49
12	57643	81714	59061	80696	60460	79653	61841	78586	63203	77494	48
13	57667	81698	59084	80679	60483	79635	61864	78568	63225	77476	47
14	57691	81681	59108	80662	60506	79618	61887	78550	63248	77458	46
15	57715	81664	59131	80644	60529	79600	61909	78532	63271	77439	45
16	57738	81647	59154	80627	60553	79583	61932	78514	63293	77421	44
17	57762	81631	59178	80610	60576	79565	61955	78496	63316	77402	43
18	57786	81614	59201	80593	60599	79547	61978	78478	63338	77384	42
19	57810	81597	59225	80576	60622	79530	62001	78460	63361	77366	41
20	57833	81580	59248	80558	60645	79512	62024	78442	63383	77347	40
21	57857	81563	59272	80541	60668	79494	62046	78424	63406	77329	39
22	57881	81546	59295	80524	60691	79477	62069	78405	63428	77310	38
23	57904	81530	59318	80507	60714	79459	62092	78387	63451	77292	37
24	57928	81513	59342	80489	60738	79441	62115	78369	63473	77273	36
25	57952	81496	59365	80472	60761	79424	62138	78351	63496	77255	35
26	57976	81479	59389	80455	60784	79406	62160	78333	63518	77236	34
27	57999	81462	59412	80438	60807	79388	62183	78315	63540	77218	33
28	58023	81445	59436	80420	60830	79371	62206	78297	63563	77199	32
29	58047	81428	59459	80403	60853	79353	62229	78279	63585	77181	31
30	58070	81412	59482	80386	60876	79335	62251	78261	63608	77162	30
31	58094	81395	59506	80368	60899	79318	62274	78243	63630	77144	29
32	58118	81378	59529	80351	60922	79300	62297	78225	63653	77125	28
33	58141	81361	59552	80334	60945	79282	62320	78206	63675	77107	27
34	58165	81344	59576	80316	60968	79264	62342	78188	63698	77088	26
35	58189	81327	59599	80299	60991	79247	62365	78170	63720	77070	25
36	58212	81310	59622	80282	61015	79229	62388	78152	63742	77051	24
37	58236	81293	59646	80264	61038	79211	62411	78134	63765	77033	23
38	58260	81276	59669	80247	61061	79193	62433	78116	63787	77014	22
39	58283	81259	59693	80230	61084	79176	62456	78098	63810	76996	21
40	58307	81242	59716	80212	61107	79158	62479	78079	63832	76977	20
41	58330	81225	59739	80195	61130	79140	62502	78061	63854	76959	19
42	58354	81208	59763	80178	61153	79122	62524	78043	63877	76940	18
43	58378	81191	59786	80160	61176	79105	62547	78025	63899	76921	17
44	58401	81174	59809	80143	61199	79087	62570	78007	63922	76903	16
45	58425	81157	59832	80125	61222	79069	62592	77988	63944	76884	15
46	58449	81140	59856	80108	61245	79051	62615	77970	63966	76866	14
47	58472	81123	59879	80091	61268	79033	62638	77952	63989	76847	13
48	58496	81106	59902	80073	61291	79015	62660	77934	64011	76828	12
49	58519	81089	59926	80056	61314	78998	62683	77916	64033	76810	11
50	58543	81072	59949	80038	61337	78980	62706	77897	64056	76791	10
51	58567	81055	59972	80021	61360	78962	62728	77879	64078	76772	9
52	58590	81038	59995	80003	61383	78944	62751	77861	64100	76754	8
53	58614	81021	60019	79986	61406	78926	62774	77843	64123	76735	7
54	58637	81004	60042	79968	61429	78908	62796	77824	64145	76717	6
55	58661	80987	60065	79951	61451	78891	62819	77806	64167	76698	5
56	58684	80970	60089	79934	61474	78873	62842	77788	64190	76679	4
57	58708	80953	60112	79916	61497	78855	62864	77769	64212	76661	3
58	58731	80936	60135	79899	61520	78837	62887	77751	64234	76642	2
59	58755	80919	60158	79881	61543	78819	62909	77733	64256	76623	1
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	54 Deg.		53 Deg.		52 Deg.		51 Deg.		50 Deg.		

M	40 Deg.		41 Deg.		42 Deg.		43 Deg.		44 Deg.		M
	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	
0	64279	76604	65606	75471	66913	74314	68200	73135	69466	71934	60
1	64301	76586	65628	75452	66935	74295	68221	73116	69487	71914	59
2	64323	76567	65650	75433	66956	74276	68242	73096	69508	71894	58
3	64346	76548	65672	75414	66978	74256	68264	73076	69529	71873	57
4	64368	76530	65694	75395	66999	74237	68285	73056	69549	71853	56
5	64390	76511	65716	75375	67021	74217	68306	73036	69570	71833	55
6	64412	76492	65738	75356	67043	74198	68327	73016	69591	71813	54
7	64435	76473	65759	75337	67064	74178	68349	72996	69612	71792	53
8	64457	76455	65781	75318	67086	74159	68370	72976	69633	71772	52
9	64479	76436	65803	75299	67107	74139	68391	72957	69654	71752	51
10	64501	76417	65825	75280	67129	74120	68412	72937	69675	71732	50
11	64524	76398	65847	75261	67151	74100	68433	72917	69696	71711	49
12	64546	76380	65869	75241	67172	74080	68455	72897	69717	71691	48
13	64568	76361	65891	75222	67194	74061	68476	72877	69737	71671	47
14	64590	76342	65913	75203	67215	74041	68497	72857	69758	71650	46
15	64612	76323	65935	75184	67237	74022	68518	72837	69779	71630	45
16	64635	76304	65956	75165	67258	74002	68539	72817	69800	71610	44
17	64657	76286	65978	75146	67280	73983	68561	72797	69821	71590	43
18	64679	76267	66000	75126	67301	73963	68582	72777	69842	71569	42
19	64701	76248	66022	75107	67323	73944	68603	72757	69862	71549	41
20	64723	76229	66044	75088	67344	73924	68624	72737	69883	71529	40
21	64746	76210	66066	75069	67366	73904	68645	72717	69904	71508	39
22	64768	76192	66088	75050	67387	73885	68666	72697	69925	71488	38
23	64790	76173	66109	75030	67409	73865	68688	72677	69946	71468	37
24	64812	76154	66131	75011	67430	73846	68709	72657	69966	71447	36
25	64834	76135	66153	74992	67452	73826	68730	72637	69987	71427	35
26	64856	76116	66175	74973	67473	73806	68751	72617	70008	71407	34
27	64878	76097	66197	74953	67495	73787	68772	72597	70029	71386	33
28	64901	76078	66218	74934	67516	73767	68793	72577	70049	71366	32
29	64923	76059	66240	74915	67538	73747	68814	72557	70070	71345	31
30	64945	76041	66262	74896	67559	73728	68835	72537	70091	71325	30
31	64967	76022	66284	74876	67580	73708	68857	72517	70112	71305	29
32	64989	76003	66306	74857	67602	73688	68878	72497	70132	71284	28
33	65011	75984	66327	74838	67623	73669	68899	72477	70153	71264	27
34	65033	75965	66349	74818	67645	73649	68920	72457	70174	71243	26
35	65055	75946	66371	74799	67666	73629	68941	72437	70195	71223	25
36	65077	75927	66393	74780	67688	73610	68962	72417	70215	71203	24
37	65099	75908	66414	74760	67709	73590	68983	72397	70236	71182	23
38	65122	75889	66436	74741	67730	73570	69004	72377	70257	71162	22
39	65144	75870	66458	74722	67752	73551	69025	72357	70277	71141	21
40	65166	75851	66480	74703	67773	73531	69046	72337	70298	71121	20
41	65188	75832	66501	74683	67795	73511	69067	72317	70319	71100	19
42	65210	75813	66523	74664	67816	73491	69088	72297	70339	71080	18
43	65232	75794	66545	74644	67837	73472	69109	72277	70360	71059	17
44	65254	75775	66566	74625	67859	73452	69130	72257	70381	71039	16
45	65276	75756	66588	74606	67880	73432	69151	72236	70401	71019	15
46	65298	75738	66610	74586	67901	73412	69172	72216	70422	70998	14
47	65320	75719	66632	74567	67923	73393	69193	72196	70443	70978	13
48	65342	75699	66653	74548	67944	73373	69214	72176	70463	70957	12
49	65364	75680	66675	74528	67965	73353	69235	72156	70484	70937	11
50	65386	75661	66697	74509	67987	73333	69256	72136	70505	70916	10
51	65408	75642	66718	74489	68008	73314	69277	72116	70525	70896	9
52	65430	75623	66740	74470	68029	73294	69298	72095	70546	70875	8
53	65452	75604	66762	74451	68051	73274	69319	72075	70567	70855	7
54	65474	75585	66783	74431	68072	73254	69340	72055	70587	70834	6
55	65496	75566	66805	74412	68093	73234	69361	72035	70608	70813	5
56	65518	75547	66827	74392	68115	73215	69382	72015	70628	70793	4
57	65540	75528	66848	74373	68136	73195	69403	71995	70649	70772	3
58	65562	75509	66870	74353	68157	73175	69424	71974	70670	70752	2
59	65584	75490	66891	74334	68179	73155	69445	71954	70690	70731	1
60	65606	75471	66913	74314	68200	73135	69466	71934	70711	70711	0
M	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	C. S.	S.	M
	49 Deg.		48 Deg.		47 Deg.		46 Deg.		45 Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.00	1.00	0.01	1.00	0.01	1
2	2.00	0.01	2.00	0.02	2.00	0.03	2
3	3.00	0.01	3.00	0.03	3.00	0.04	3
4	4.00	0.02	4.00	0.03	4.00	0.05	4
5	5.00	0.02	5.00	0.04	5.00	0.07	5
6	6.00	0.03	6.00	0.05	6.00	0.08	6
7	7.00	0.03	7.00	0.06	7.00	0.09	7
8	8.00	0.03	8.00	0.07	8.00	0.10	8
9	9.00	0.04	9.00	0.08	9.00	0.12	9
10	10.00	0.04	10.00	0.09	10.00	0.13	10
11	11.00	0.05	11.00	0.10	11.00	0.14	11
12	12.00	0.05	12.00	0.10	12.00	0.16	12
13	13.00	0.06	13.00	0.11	13.00	0.17	13
14	14.00	0.06	14.00	0.12	14.00	0.18	14
15	15.00	0.07	15.00	0.13	15.00	0.20	15
16	16.00	0.07	16.00	0.14	16.00	0.21	16
17	17.00	0.07	17.00	0.15	17.00	0.22	17
18	18.00	0.08	18.00	0.16	18.00	0.24	18
19	19.00	0.08	19.00	0.17	19.00	0.25	19
20	20.00	0.09	20.00	0.17	20.00	0.26	20
21	21.00	0.09	21.00	0.18	21.00	0.27	21
22	22.00	0.10	22.00	0.19	22.00	0.29	22
23	23.00	0.10	23.00	0.20	23.00	0.30	23
24	24.00	0.10	24.00	0.21	24.00	0.31	24
25	25.00	0.11	25.00	0.22	25.00	0.33	25
26	26.00	0.11	26.00	0.23	26.00	0.34	26
27	27.00	0.12	27.00	0.24	27.00	0.35	27
28	28.00	0.12	28.00	0.24	28.00	0.37	28
29	29.00	0.13	29.00	0.25	29.00	0.38	29
30	30.00	0.13	30.00	0.26	30.00	0.39	30
31	31.00	0.14	31.00	0.27	31.00	0.41	31
32	32.00	0.14	32.00	0.28	32.00	0.42	32
33	33.00	0.14	33.00	0.29	33.00	0.43	33
34	34.00	0.15	34.00	0.30	34.00	0.45	34
35	35.00	0.15	35.00	0.31	35.00	0.46	35
36	36.00	0.16	36.00	0.31	36.00	0.47	36
37	37.00	0.16	37.00	0.32	37.00	0.48	37
38	38.00	0.17	38.00	0.33	38.00	0.50	38
39	39.00	0.17	39.00	0.34	39.00	0.51	39
40	40.00	0.17	40.00	0.35	40.00	0.52	40
41	41.00	0.18	41.00	0.36	41.00	0.54	41
42	42.00	0.18	42.00	0.37	42.00	0.55	42
43	43.00	0.19	43.00	0.38	43.00	0.56	43
44	44.00	0.19	44.00	0.38	44.00	0.58	44
45	45.00	0.20	45.00	0.39	45.00	0.59	45
46	46.00	0.20	46.00	0.40	46.00	0.60	46
47	47.00	0.21	47.00	0.41	47.00	0.62	47
48	48.00	0.21	48.00	0.42	48.00	0.63	48
49	49.00	0.21	49.00	0.43	49.00	0.64	49
50	50.00	0.22	50.00	0.44	50.00	0.65	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	51.00	0.22	51.00	0.45	51.00	0.67	51
52	52.00	0.23	52.00	0.45	52.00	0.68	52
53	53.00	0.23	53.00	0.46	53.00	0.69	53
54	54.00	0.24	54.00	0.47	54.00	0.71	54
55	55.00	0.24	55.00	0.48	55.00	0.72	55
56	56.00	0.24	56.00	0.49	56.00	0.73	56
57	57.00	0.25	57.00	0.50	57.00	0.75	57
58	58.00	0.25	58.00	0.51	57.99	0.76	58
59	59.00	0.26	59.00	0.51	58.99	0.77	59
60	60.00	0.26	60.00	0.52	59.99	0.79	60
61	61.00	0.27	61.00	0.53	60.99	0.80	61
62	62.00	0.27	62.00	0.54	61.99	0.81	62
63	63.00	0.27	63.00	0.55	62.99	0.82	63
64	64.00	0.28	64.00	0.56	63.99	0.84	64
65	65.00	0.28	65.00	0.57	64.99	0.85	65
66	66.00	0.29	66.00	0.58	65.99	0.86	66
67	67.00	0.29	67.00	0.58	66.99	0.88	67
68	68.00	0.30	68.00	0.59	67.99	0.89	68
69	69.00	0.30	69.00	0.60	68.99	0.90	69
70	70.00	0.31	70.00	0.61	69.99	0.92	70
71	71.00	0.31	71.00	0.62	70.99	0.93	71
72	72.00	0.31	72.00	0.63	71.99	0.94	72
73	73.00	0.32	73.00	0.64	72.99	0.96	73
74	74.00	0.32	74.00	0.65	73.99	0.97	74
75	75.00	0.33	75.00	0.65	74.99	0.98	75
76	76.00	0.33	76.00	0.66	75.99	0.99	76
77	77.00	0.34	77.00	0.67	76.99	1.01	77
78	78.00	0.34	78.00	0.68	77.99	1.02	78
79	79.00	0.34	79.00	0.69	78.99	1.03	79
80	80.00	0.35	80.00	0.70	79.99	1.05	80
81	81.00	0.35	81.00	0.71	80.99	1.06	81
82	82.00	0.36	82.00	0.72	81.99	1.07	82
83	83.00	0.36	83.00	0.72	82.99	1.09	83
84	84.00	0.37	84.00	0.73	83.99	1.10	84
85	85.00	0.37	85.00	0.74	84.99	1.11	85
86	86.00	0.38	86.00	0.75	85.99	1.13	86
87	87.00	0.38	87.00	0.76	86.99	1.14	87
88	88.00	0.38	88.00	0.77	87.99	1.15	88
89	89.00	0.39	89.00	0.78	88.99	1.16	89
90	90.00	0.39	90.00	0.79	89.99	1.18	90
91	91.00	0.40	91.00	0.79	90.99	1.19	91
92	92.00	0.40	92.00	0.80	91.99	1.20	92
93	93.00	0.41	93.00	0.81	92.99	1.22	93
94	94.00	0.41	94.00	0.82	93.99	1.23	94
95	95.00	0.41	95.00	0.83	94.99	1.24	95
96	96.00	0.42	96.00	0.84	95.99	1.26	96
97	97.00	0.42	97.00	0.85	96.99	1.27	97
98	98.00	0.43	98.00	0.86	97.99	1.28	98
99	99.00	0.43	99.00	0.86	98.99	1.30	99
100	100.00	0.44	100.00	0.87	99.99	1.31	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.02	1.00	0.02	1.00	0.03	1.00	0.03	
2	2.00	0.03	2.00	0.04	2.00	0.05	2.00	0.06	2
3	3.00	0.05	3.00	0.07	3.00	0.08	3.00	0.09	3
4	4.00	0.07	4.00	0.09	4.00	0.10	4.00	0.12	4
5	5.00	0.09	5.00	0.11	5.00	0.13	5.00	0.15	5
6	6.00	0.10	6.00	0.13	6.00	0.16	6.00	0.18	6
7	7.00	0.12	7.00	0.15	7.00	0.18	7.00	0.21	7
8	8.00	0.14	8.00	0.17	8.00	0.21	8.00	0.25	8
9	9.00	0.16	9.00	0.20	9.00	0.24	9.00	0.28	9
10	10.00	0.17	10.00	0.22	10.00	0.26	10.00	0.31	10
11	11.00	0.19	11.00	0.24	11.00	0.28	10.99	0.34	11
12	12.00	0.21	12.00	0.26	12.00	0.31	11.99	0.37	12
13	13.00	0.23	13.00	0.28	13.00	0.34	12.99	0.40	13
14	14.00	0.24	14.00	0.31	14.00	0.37	13.99	0.43	14
15	15.00	0.26	15.00	0.33	14.99	0.39	14.99	0.46	15
16	16.00	0.28	16.00	0.35	15.99	0.42	15.99	0.49	16
17	17.00	0.30	17.00	0.37	16.99	0.45	16.99	0.52	17
18	18.00	0.31	18.00	0.39	17.99	0.47	17.99	0.55	18
19	19.00	0.33	19.00	0.41	18.99	0.50	18.99	0.58	19
20	20.00	0.35	20.00	0.44	19.99	0.52	19.99	0.61	20
21	21.00	0.37	21.00	0.46	20.99	0.55	20.99	0.64	21
22	22.00	0.38	21.99	0.48	21.99	0.58	21.99	0.67	22
23	23.00	0.40	22.99	0.50	22.99	0.60	22.99	0.70	23
24	24.00	0.42	23.99	0.52	23.99	0.63	23.99	0.73	24
25	25.00	0.44	24.99	0.55	24.99	0.65	24.99	0.76	25
26	26.00	0.45	25.99	0.57	25.99	0.68	25.99	0.79	26
27	27.00	0.47	26.99	0.59	26.99	0.71	26.99	0.83	27
28	28.00	0.49	27.99	0.61	27.99	0.73	27.99	0.86	28
29	29.00	0.51	28.99	0.63	28.99	0.76	28.99	0.89	29
30	30.00	0.52	29.99	0.65	29.99	0.79	29.99	0.92	30
31	31.00	0.54	30.99	0.68	30.99	0.81	30.99	0.95	31
32	32.00	0.56	31.99	0.70	31.99	0.84	31.99	0.98	32
33	32.99	0.58	32.99	0.72	32.99	0.86	32.98	1.01	33
34	33.99	0.59	33.99	0.74	33.99	0.89	33.98	1.04	34
35	34.99	0.61	34.99	0.76	34.99	0.92	34.98	1.07	35
36	35.99	0.63	35.99	0.79	35.99	0.94	35.98	1.10	36
37	36.99	0.65	36.99	0.81	36.99	0.97	36.98	1.13	37
38	37.99	0.66	37.99	0.83	37.99	0.99	37.98	1.16	38
39	38.99	0.68	38.99	0.85	38.99	1.02	38.98	1.19	39
40	39.99	0.70	39.99	0.87	39.99	1.05	39.98	1.22	40
41	40.99	0.72	40.99	0.89	40.99	1.07	40.98	1.25	41
42	41.99	0.73	41.99	0.92	41.99	1.10	41.98	1.28	42
43	42.99	0.75	42.99	0.94	42.99	1.13	42.98	1.31	43
44	43.99	0.77	43.99	0.96	43.99	1.15	43.98	1.34	44
45	44.99	0.79	44.99	0.98	44.99	1.18	44.98	1.37	45
46	45.99	0.80	45.99	1.00	45.99	1.20	45.98	1.40	46
47	46.99	0.82	46.99	1.03	46.99	1.23	46.98	1.44	47
48	47.99	0.84	47.99	1.05	47.98	1.26	47.98	1.47	48
49	48.99	0.86	48.99	1.07	48.98	1.28	48.98	1.50	49
50	49.99	0.87	49.99	1.09	49.98	1.31	49.98	1.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.99	0.89	50.99	1.11	50.98	1.34	50.98	1.56	51
52	51.99	0.91	51.99	1.13	51.98	1.36	51.98	1.59	52
53	52.99	0.92	52.99	1.16	52.98	1.39	52.98	1.62	53
54	53.99	0.94	53.99	1.18	53.98	1.41	53.97	1.65	54
55	54.99	0.96	54.99	1.20	54.98	1.44	54.97	1.68	55
56	55.99	0.98	55.99	1.22	55.98	1.47	55.97	1.71	56
57	56.99	0.99	56.99	1.24	56.98	1.49	56.97	1.74	57
58	57.99	1.01	57.99	1.27	57.98	1.52	57.97	1.77	58
59	58.99	1.03	58.99	1.29	58.98	1.54	58.97	1.80	59
60	59.99	1.05	59.99	1.31	59.98	1.57	59.97	1.83	60
61	60.99	1.06	60.99	1.33	60.98	1.60	60.97	1.86	61
62	61.99	1.08	61.99	1.35	61.98	1.62	61.97	1.89	62
63	62.99	1.10	62.99	1.37	62.98	1.65	62.97	1.92	63
64	63.99	1.12	63.98	1.40	63.98	1.68	63.97	1.95	64
65	64.99	1.13	64.98	1.42	64.98	1.70	64.97	1.99	65
66	65.99	1.15	65.98	1.44	65.98	1.73	65.97	2.02	66
67	66.99	1.17	66.98	1.46	66.98	1.75	66.97	2.05	67
68	67.99	1.19	67.98	1.48	67.98	1.78	67.97	2.08	68
69	68.99	1.20	68.98	1.51	68.98	1.81	68.97	2.11	69
70	69.99	1.22	69.98	1.53	69.98	1.83	69.97	2.14	70
71	70.99	1.24	70.98	1.55	70.98	1.86	70.97	2.17	71
72	71.99	1.26	71.98	1.57	71.98	1.88	71.97	2.20	72
73	72.99	1.27	72.98	1.59	72.97	1.91	72.97	2.23	73
74	73.99	1.29	73.98	1.61	73.97	1.94	73.97	2.26	74
75	74.99	1.31	74.98	1.64	74.97	1.96	74.97	2.29	75
76	75.99	1.33	75.98	1.66	75.97	1.99	75.96	2.32	76
77	76.99	1.34	76.98	1.68	76.97	2.02	76.96	2.35	77
78	77.99	1.36	77.98	1.70	77.97	2.04	77.96	2.38	78
79	78.99	1.38	78.98	1.72	78.97	2.07	78.96	2.41	79
80	79.99	1.40	79.98	1.75	79.97	2.09	79.96	2.44	80
81	80.99	1.41	80.98	1.77	80.97	2.12	80.96	2.47	81
82	81.99	1.43	81.98	1.79	81.97	2.15	81.96	2.50	82
83	82.99	1.45	82.98	1.81	82.97	2.17	82.96	2.53	83
84	83.99	1.47	83.98	1.83	83.97	2.20	83.96	2.57	84
85	84.99	1.48	84.98	1.85	84.97	2.23	84.96	2.60	85
86	85.99	1.50	85.98	1.88	85.97	2.25	85.96	2.63	86
87	86.99	1.52	86.98	1.90	86.97	2.28	86.96	2.66	87
88	87.99	1.54	87.98	1.92	87.97	2.30	87.96	2.69	88
89	88.99	1.55	88.98	1.94	88.97	2.33	88.96	2.72	89
90	89.99	1.57	89.98	1.96	89.97	2.36	89.96	2.75	90
91	90.99	1.59	90.98	1.99	90.97	2.38	90.96	2.78	91
92	91.99	1.61	91.98	2.01	91.97	2.41	91.96	2.81	92
93	92.99	1.62	92.98	2.03	92.97	2.43	92.96	2.84	93
94	93.99	1.64	93.98	2.05	93.97	2.46	93.96	2.87	94
95	94.99	1.66	94.98	2.07	94.97	2.49	94.96	2.90	95
96	95.99	1.68	95.98	2.09	95.97	2.51	95.96	2.94	96
97	96.99	1.69	96.98	2.12	96.97	2.54	96.95	2.96	97
98	97.99	1.71	97.98	2.14	97.97	2.57	97.95	2.99	98
99	98.98	1.73	98.98	2.16	98.97	2.59	98.95	3.02	99
100	99.98	1.75	99.98	2.18	99.97	2.62	99.95	3.05	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	
1	1.00	0.03	1.00	0.04	1.00	0.04	1.00	0.05	1
2	2.00	0.07	2.00	0.08	2.00	0.09	2.00	0.10	2
3	3.00	0.10	3.00	0.12	3.00	0.13	3.00	0.14	3
4	4.00	0.14	4.00	0.16	4.00	0.17	4.00	0.19	4
5	5.00	0.17	5.00	0.20	5.00	0.22	4.99	0.24	5
6	6.00	0.21	6.00	0.24	5.99	0.26	5.99	0.29	6
7	7.00	0.24	6.99	0.27	6.99	0.31	6.99	0.34	7
8	7.99	0.28	7.99	0.31	7.99	0.35	7.99	0.38	8
9	8.99	0.31	8.99	0.35	8.99	0.39	8.99	0.43	9
10	9.99	0.35	9.99	0.39	9.99	0.44	9.99	0.48	10
11	10.99	0.38	10.99	0.43	10.99	0.48	10.99	0.53	11
12	11.99	0.42	11.99	0.47	11.99	0.52	11.99	0.58	12
13	12.99	0.45	12.99	0.51	12.99	0.57	12.99	0.62	13
14	13.99	0.49	13.99	0.55	13.99	0.61	13.98	0.67	14
15	14.99	0.52	14.99	0.59	14.99	0.65	14.98	0.72	15
16	15.99	0.56	15.99	0.63	15.99	0.70	15.98	0.77	16
17	16.99	0.59	16.99	0.67	16.98	0.74	16.98	0.82	17
18	17.99	0.63	17.99	0.71	17.98	0.79	17.98	0.86	18
19	18.99	0.66	18.99	0.75	18.98	0.83	18.98	0.91	19
20	19.99	0.70	19.98	0.79	19.98	0.87	19.98	0.96	20
21	20.99	0.73	20.98	0.82	20.98	0.92	20.98	1.01	21
22	21.99	0.77	21.98	0.86	21.98	0.96	21.97	1.06	22
23	22.99	0.80	22.98	0.90	22.98	1.00	22.97	1.10	23
24	23.99	0.84	23.98	0.94	23.98	1.05	23.97	1.15	24
25	24.98	0.87	24.98	0.98	24.98	1.09	24.97	1.20	25
26	25.98	0.91	25.98	1.02	25.98	1.13	25.97	1.25	26
27	26.98	0.94	26.98	1.06	26.97	1.18	26.97	1.30	27
28	27.98	0.98	27.98	1.10	27.97	1.22	27.97	1.34	28
29	28.98	1.01	28.98	1.14	28.97	1.26	28.97	1.39	29
30	29.98	1.05	29.98	1.18	29.97	1.31	29.97	1.44	30
31	30.98	1.08	30.98	1.22	30.97	1.35	30.96	1.49	31
32	31.98	1.12	31.98	1.26	31.97	1.40	31.96	1.54	32
33	32.98	1.15	32.97	1.30	32.97	1.44	32.96	1.58	33
34	33.98	1.19	33.97	1.33	33.97	1.48	33.96	1.63	34
35	34.98	1.22	34.97	1.37	34.97	1.53	34.96	1.68	35
36	35.98	1.26	35.97	1.41	35.97	1.57	35.96	1.73	36
37	36.98	1.29	36.97	1.45	36.96	1.61	36.96	1.78	37
38	37.98	1.33	37.97	1.49	37.96	1.66	37.96	1.82	38
39	38.98	1.36	38.97	1.53	38.96	1.70	38.96	1.87	39
40	39.98	1.40	39.97	1.57	39.96	1.75	39.95	1.92	40
41	40.98	1.43	40.97	1.61	40.96	1.77	40.95	1.97	41
42	41.97	1.47	41.97	1.65	41.96	1.83	41.95	2.02	42
43	42.97	1.50	42.97	1.69	42.96	1.88	42.95	2.06	43
44	43.97	1.54	43.97	1.73	43.96	1.92	43.95	2.11	44
45	44.97	1.57	44.97	1.77	44.96	1.96	44.95	2.16	45
46	45.97	1.61	45.96	1.81	45.96	2.01	45.95	2.21	46
47	46.97	1.64	46.96	1.85	46.96	2.05	46.95	2.25	47
48	47.97	1.68	47.96	1.88	47.95	2.09	47.95	2.30	48
49	48.97	1.71	48.96	1.92	48.95	2.14	48.94	2.35	49
50	49.97	1.74	49.96	1.96	49.95	2.18	49.94	2.40	50
Distance.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.97	1.78	50.96	2.00	50.95	2.22	50.94	2.45	51
52	51.97	1.81	51.96	2.04	51.95	2.27	51.94	2.50	52
53	52.97	1.85	52.96	2.08	52.95	2.31	52.94	2.54	53
54	53.97	1.88	53.96	2.12	53.95	2.36	53.94	2.59	54
55	54.97	1.92	54.96	2.16	54.95	2.40	54.94	2.64	55
56	55.97	1.95	55.96	2.20	55.95	2.44	55.94	2.69	56
57	56.97	1.99	56.96	2.24	56.95	2.49	56.93	2.73	57
58	57.96	2.02	57.96	2.28	57.94	2.53	57.93	2.78	58
59	58.96	2.06	58.95	2.32	58.94	2.57	58.93	2.83	59
60	59.96	2.09	59.95	2.36	59.94	2.62	59.93	2.88	60
61	60.96	2.13	60.95	2.39	60.94	2.66	60.93	2.93	61
62	61.96	2.16	61.95	2.43	61.94	2.70	61.93	2.97	62
63	62.96	2.20	62.95	2.47	62.94	2.75	62.93	3.02	63
64	63.96	2.23	63.95	2.51	63.94	2.79	63.93	3.07	64
65	64.96	2.27	64.95	2.55	64.94	2.84	64.93	3.12	65
66	65.96	2.30	65.95	2.59	65.94	2.88	65.92	3.17	66
67	66.96	2.34	66.95	2.63	66.94	2.92	66.92	3.21	67
68	67.96	2.37	67.95	2.67	67.94	2.97	67.92	3.26	68
69	68.96	2.41	68.95	2.71	68.93	3.01	68.92	3.31	69
70	69.96	2.44	69.95	2.75	69.93	3.05	69.92	3.36	70
71	70.96	2.48	70.95	2.79	70.93	3.10	70.92	3.41	71
72	71.96	2.51	71.94	2.83	71.93	3.14	71.92	3.45	72
73	72.96	2.55	72.94	2.87	72.93	3.18	72.92	3.50	73
74	73.95	2.58	73.94	2.91	73.93	3.23	73.91	3.55	74
75	74.95	2.62	74.94	2.94	74.93	3.27	74.91	3.60	75
76	75.95	2.65	75.94	2.98	75.93	3.31	75.91	3.65	76
77	76.95	2.69	76.94	3.02	76.93	3.36	76.91	3.70	77
78	77.95	2.72	77.94	3.06	77.93	3.40	77.91	3.74	78
79	78.95	2.76	78.94	3.10	78.92	3.45	78.91	3.79	79
80	79.95	2.79	79.94	3.14	79.92	3.49	79.91	3.84	80
81	80.95	2.83	80.94	3.18	80.92	3.53	80.91	3.89	81
82	81.95	2.86	81.94	3.22	81.92	3.58	81.91	3.93	82
83	82.95	2.90	82.94	3.26	82.92	3.62	82.90	3.98	83
84	83.95	2.93	83.94	3.30	83.92	3.66	83.90	4.03	84
85	84.95	2.97	84.93	3.34	84.92	3.71	84.90	4.08	85
86	85.95	3.00	85.93	3.38	85.92	3.75	85.90	4.13	86
87	86.95	3.04	86.93	3.42	86.92	3.79	86.90	4.17	87
88	87.95	3.07	87.93	3.45	87.92	3.84	87.90	4.22	88
89	88.95	3.11	88.93	3.49	88.92	3.88	88.90	4.27	89
90	89.95	3.14	89.93	3.53	89.91	3.93	89.90	4.32	90
91	90.95	3.18	90.93	3.57	90.91	3.97	90.90	4.37	91
92	91.94	3.21	91.93	3.61	91.91	4.01	91.89	4.41	92
93	92.94	3.25	92.93	3.65	92.91	4.06	92.89	4.46	93
94	93.94	3.28	93.93	3.69	93.91	4.10	93.89	4.51	94
95	94.94	3.32	94.93	3.73	94.91	4.14	94.89	4.56	95
96	95.94	3.35	95.93	3.77	95.91	4.19	95.89	4.61	96
97	96.94	3.39	96.93	3.81	96.91	4.23	96.89	4.65	97
98	97.94	3.42	97.92	3.85	97.91	4.27	97.89	4.70	98
99	98.94	3.46	98.92	3.89	98.91	4.32	98.89	4.75	99
100	99.94	3.49	99.92	3.93	99.91	4.36	99.88	4.80	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	
1	1.00	0.05	1.00	0.06	1.00	0.06	1.00	0.06	1
2	2.00	0.10	2.00	0.11	2.00	0.12	2.00	0.13	2
3	3.00	0.16	3.00	0.17	2.99	0.18	2.99	0.20	3
4	3.99	0.21	3.99	0.23	3.99	0.24	3.99	0.26	4
5	4.99	0.26	4.99	0.28	4.99	0.31	4.99	0.33	5
6	5.99	0.31	5.99	0.34	5.99	0.37	5.99	0.39	6
7	6.99	0.37	6.99	0.40	6.99	0.43	6.99	0.46	7
8	7.99	0.42	7.99	0.45	7.99	0.49	7.98	0.52	8
9	8.99	0.47	8.99	0.51	8.98	0.55	8.98	0.59	9
10	9.99	0.52	9.98	0.57	9.98	0.61	9.98	0.65	10
11	10.98	0.58	10.98	0.62	10.98	0.67	10.98	0.72	11
12	11.98	0.63	11.98	0.68	11.98	0.73	11.97	0.78	12
13	12.98	0.68	12.98	0.73	12.98	0.79	12.97	0.85	13
14	13.98	0.73	13.98	0.79	13.97	0.85	13.97	0.92	14
15	14.98	0.79	14.98	0.85	14.97	0.92	14.97	0.98	15
16	15.98	0.84	15.97	0.91	15.97	0.98	15.97	1.05	16
17	16.98	0.89	16.97	0.96	16.97	1.04	16.96	1.11	17
18	17.98	0.94	17.97	1.02	17.97	1.10	17.96	1.18	18
19	18.98	0.99	18.97	1.08	18.96	1.16	18.96	1.24	19
20	19.97	1.05	19.97	1.13	19.96	1.22	19.95	1.31	20
21	20.97	1.10	20.97	1.19	20.96	1.28	20.96	1.37	21
22	21.97	1.15	21.96	1.25	21.96	1.34	21.95	1.44	22
23	22.97	1.20	22.96	1.30	22.96	1.40	22.95	1.50	23
24	23.97	1.26	23.96	1.36	23.96	1.47	23.95	1.57	24
25	24.97	1.31	24.96	1.42	24.95	1.53	24.95	1.64	25
26	25.96	1.36	25.96	1.47	25.95	1.59	25.94	1.70	26
27	26.96	1.41	26.96	1.53	26.95	1.65	26.94	1.77	27
28	27.96	1.47	27.95	1.59	27.95	1.71	27.94	1.83	28
29	28.96	1.52	28.95	1.64	28.95	1.77	28.94	1.90	29
30	29.96	1.57	29.95	1.70	29.94	1.83	29.94	1.96	30
31	30.96	1.62	30.95	1.76	30.94	1.89	30.93	2.03	31
32	31.96	1.67	31.95	1.81	31.94	1.95	31.93	2.09	32
33	32.95	1.73	32.95	1.87	32.94	2.01	32.93	2.16	33
34	33.95	1.78	33.95	1.93	33.94	2.08	33.93	2.22	34
35	34.95	1.83	34.94	1.98	34.93	2.14	34.92	2.29	35
36	35.95	1.88	35.94	2.04	35.93	2.20	35.92	2.35	36
37	36.95	1.94	36.94	2.10	36.93	2.26	36.92	2.42	37
38	37.95	1.99	37.94	2.15	37.93	2.32	37.92	2.49	38
39	38.95	2.04	38.94	2.21	38.93	2.38	38.92	2.55	39
40	39.95	2.09	39.94	2.27	39.93	2.44	39.91	2.62	40
41	40.94	2.15	40.93	2.32	40.92	2.50	40.91	2.68	41
42	41.94	2.20	41.93	2.38	41.92	2.56	41.91	2.75	42
43	42.94	2.25	42.93	2.44	42.92	2.63	42.91	2.81	43
44	43.94	2.30	43.93	2.49	43.92	2.69	43.91	2.88	44
45	44.94	2.36	44.93	2.55	44.92	2.75	44.90	2.94	45
46	45.94	2.41	45.93	2.61	45.91	2.81	45.90	3.01	46
47	46.94	2.46	46.92	2.66	46.91	2.87	46.90	3.07	47
48	47.93	2.51	47.92	2.72	47.91	2.93	47.90	3.14	48
49	48.93	2.56	48.92	2.78	48.91	2.99	48.90	3.20	49
50	49.93	2.62	49.92	2.83	49.91	3.05	49.89	3.27	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.93	2.67	50.92	2.89	50.90	3.11	50.89	3.34	51
52	51.93	2.72	51.92	2.95	51.90	3.17	51.89	3.40	52
53	52.93	2.77	52.91	3.00	52.90	3.24	52.89	3.47	53
54	53.93	2.83	53.91	3.06	53.90	3.30	53.88	3.53	54
55	54.92	2.88	54.91	3.12	54.90	3.36	54.88	3.60	55
56	55.92	2.93	55.91	3.17	55.90	3.42	55.88	3.66	56
57	56.92	2.98	56.91	3.23	56.89	3.48	56.88	3.73	57
58	57.92	3.04	57.91	3.29	57.89	3.54	57.88	3.79	58
59	58.92	3.09	58.91	3.34	58.89	3.60	58.87	3.86	59
60	59.92	3.14	59.90	3.40	59.89	3.66	59.87	3.92	60
61	60.92	3.19	60.90	3.46	60.89	3.72	60.87	3.99	61
62	61.92	3.24	61.90	3.51	61.88	3.79	61.87	4.05	62
63	62.91	3.30	62.90	3.57	62.88	3.85	62.87	4.12	63
64	63.91	3.35	63.90	3.63	63.88	3.91	63.86	4.19	64
65	64.91	3.40	64.90	3.69	64.88	3.97	64.86	4.25	65
66	65.91	3.45	65.89	3.74	65.88	4.03	65.86	4.32	66
67	66.91	3.51	66.89	3.80	66.88	4.09	66.86	4.38	67
68	67.91	3.56	67.89	3.86	67.87	4.15	67.85	4.45	68
69	68.91	3.61	68.89	3.91	68.87	4.21	68.85	4.51	69
70	69.90	3.66	69.89	3.97	69.87	4.27	69.85	4.58	70
71	70.90	3.72	70.89	4.03	70.87	4.33	70.85	4.64	71
72	71.90	3.77	71.88	4.08	71.87	4.40	71.85	4.71	72
73	72.90	3.82	72.88	4.14	72.86	4.46	72.84	4.77	73
74	73.90	3.87	73.88	4.20	73.86	4.52	73.84	4.84	74
75	74.90	3.93	74.88	4.25	74.86	4.58	74.84	4.91	75
76	75.90	3.98	75.88	4.31	75.86	4.64	75.84	4.97	76
77	76.89	4.03	76.88	4.37	76.86	4.70	76.84	5.04	77
78	77.89	4.08	77.87	4.42	77.85	4.76	77.83	5.10	78
79	78.89	4.13	78.87	4.48	78.85	4.82	78.83	5.17	79
80	79.89	4.19	79.87	4.54	79.85	4.88	79.83	5.23	80
81	80.89	4.24	80.87	4.59	80.85	4.94	80.83	5.30	81
82	81.89	4.29	81.87	4.65	81.85	5.01	81.82	5.36	82
83	82.89	4.34	82.87	4.71	82.85	5.07	82.82	5.43	83
84	83.88	4.40	83.86	4.76	83.84	5.13	83.82	5.49	84
85	84.88	4.45	84.86	4.82	84.84	5.19	84.82	5.56	85
86	85.88	4.50	85.86	4.88	85.84	5.25	85.82	5.62	86
87	86.88	4.55	86.86	4.93	86.84	5.31	86.81	5.69	87
88	87.88	4.61	87.86	4.99	87.84	5.37	87.81	5.76	88
89	88.88	4.66	88.86	5.05	88.83	5.43	88.81	5.82	89
90	89.88	4.71	89.86	5.10	89.83	5.49	89.81	5.89	90
91	90.88	4.76	90.85	5.16	90.83	5.56	90.81	5.95	91
92	91.87	4.81	91.85	5.22	91.83	5.62	91.80	6.02	92
93	92.87	4.87	92.85	5.27	92.83	5.68	92.80	6.08	93
94	93.87	4.92	93.85	5.33	93.82	5.74	93.80	6.15	94
95	94.87	4.97	94.85	5.39	94.82	5.80	94.80	6.21	95
96	95.87	5.02	95.85	5.44	95.82	5.86	95.79	6.28	96
97	96.87	5.08	96.84	5.50	96.82	5.92	96.79	6.34	97
98	97.87	5.13	97.84	5.56	97.82	5.98	97.79	6.41	98
99	98.86	5.18	98.84	5.61	98.82	6.04	98.79	6.47	99
100	99.86	5.23	99.84	5.67	99.81	6.10	99.79	6.54	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.07	1.00	0.07	1.00	0.08	1.00	0.08	1
2	2.00	0.14	1.99	0.15	1.99	0.16	1.99	0.17	2
3	2.99	0.21	2.99	0.22	2.99	0.24	2.99	0.25	3
4	3.99	0.28	3.99	0.30	3.99	0.31	3.98	0.33	4
5	4.99	0.35	4.99	0.37	4.98	0.39	4.98	0.41	5
6	5.99	0.42	5.98	0.44	5.98	0.47	5.98	0.50	6
7	6.98	0.49	6.98	0.52	6.98	0.55	6.97	0.58	7
8	7.98	0.56	7.98	0.59	7.98	0.63	7.97	0.66	8
9	8.98	0.63	8.98	0.67	8.97	0.71	8.97	0.75	9
10	9.98	0.70	9.97	0.74	9.97	0.78	9.97	0.83	10
11	10.97	0.77	10.97	0.82	10.97	0.86	10.96	0.91	11
12	11.97	0.84	11.97	0.89	11.96	0.94	11.96	0.99	12
13	12.97	0.91	12.96	0.96	12.96	1.02	12.96	1.08	13
14	13.97	0.98	13.96	1.04	13.96	1.10	13.95	1.16	14
15	14.96	1.05	14.96	1.11	14.95	1.18	14.95	1.24	15
16	15.96	1.12	15.96	1.19	15.95	1.26	15.95	1.32	16
17	16.96	1.19	16.95	1.26	16.95	1.33	16.94	1.41	17
18	17.96	1.26	17.95	1.33	17.94	1.41	17.94	1.49	18
19	18.95	1.33	18.95	1.40	18.94	1.49	18.93	1.57	19
20	19.95	1.40	19.95	1.48	19.94	1.57	19.93	1.66	20
21	20.95	1.46	20.94	1.56	20.94	1.65	20.93	1.74	21
22	21.95	1.53	21.94	1.63	21.93	1.73	21.92	1.82	22
23	22.94	1.60	22.94	1.70	22.93	1.80	22.92	1.90	23
24	23.94	1.67	23.93	1.78	23.93	1.88	23.92	1.99	24
25	24.94	1.74	24.93	1.85	24.92	1.96	24.91	2.07	25
26	25.94	1.81	25.93	1.93	25.92	2.04	25.91	2.15	26
27	26.93	1.88	26.93	2.00	26.92	2.12	26.91	2.24	27
28	27.93	1.95	27.92	2.08	27.91	2.20	27.90	2.32	28
29	28.93	2.02	28.92	2.15	28.91	2.28	28.90	2.40	29
30	29.93	2.09	29.92	2.22	29.91	2.35	29.90	2.48	30
31	30.92	2.16	30.91	2.30	30.90	2.43	30.89	2.57	31
32	31.92	2.23	31.91	2.37	31.90	2.51	31.89	2.65	32
33	32.92	2.30	32.91	2.45	32.90	2.59	32.89	2.73	33
34	33.92	2.37	33.91	2.52	33.90	2.67	33.88	2.82	34
35	34.91	2.44	34.90	2.59	34.89	2.75	34.88	2.90	35
36	35.91	2.51	35.90	2.67	35.89	2.82	35.88	2.98	36
37	36.91	2.58	36.90	2.74	36.89	2.90	36.87	3.06	37
38	37.91	2.65	37.90	2.82	37.88	2.98	37.87	3.15	38
39	38.90	2.72	38.89	2.89	38.88	3.06	38.87	3.23	39
40	39.90	2.79	39.89	2.96	39.88	3.14	39.86	3.31	40
41	40.90	2.86	40.89	3.04	40.87	3.22	40.86	3.40	41
42	41.90	2.93	41.88	3.11	41.87	3.30	41.86	3.48	42
43	42.90	3.00	42.88	3.19	42.87	3.37	42.85	3.56	43
44	43.89	3.07	43.88	3.26	43.86	3.45	43.85	3.64	44
45	44.89	3.14	44.88	3.33	44.86	3.53	44.85	3.73	45
46	45.89	3.21	45.87	3.41	45.86	3.61	45.84	3.81	46
47	46.89	3.28	46.87	3.48	46.86	3.69	46.84	3.89	47
48	47.88	3.35	47.87	3.56	47.85	3.77	47.84	3.97	48
49	48.88	3.42	48.87	3.63	48.85	3.84	48.83	4.06	49
50	49.88	3.49	49.86	3.71	49.85	3.92	49.83	4.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.88	3.56	50.86	3.78	50.84	4.00	50.82	4.22	51
52	51.87	3.63	51.86	3.85	51.84	4.08	51.82	4.31	52
53	52.87	3.70	52.85	3.93	52.84	4.16	52.82	4.39	53
54	53.87	3.77	53.85	4.00	53.83	4.24	53.81	4.47	54
55	54.87	3.84	54.85	4.08	54.83	4.32	54.81	4.55	55
56	55.86	3.91	55.85	4.15	55.83	4.39	55.81	4.64	56
57	56.86	3.98	56.84	4.22	56.82	4.47	56.80	4.72	57
58	57.86	4.05	57.84	4.30	57.82	4.55	57.80	4.80	58
59	58.86	4.12	58.84	4.37	58.82	4.63	58.80	4.89	59
60	59.85	4.19	59.84	4.45	59.82	4.71	59.79	4.97	60
61	60.85	4.26	60.83	4.52	60.81	4.79	60.79	5.05	61
62	61.85	4.32	61.83	4.59	61.81	4.86	61.79	5.13	62
63	62.85	4.39	62.83	4.67	62.81	4.94	62.78	5.22	63
64	63.84	4.46	63.82	4.74	63.80	5.02	63.78	5.30	64
65	64.84	4.53	64.82	4.82	64.80	5.10	64.78	5.38	65
66	65.84	4.60	65.82	4.89	65.80	5.18	65.77	5.47	66
67	66.84	4.67	66.82	4.97	66.79	5.26	66.77	5.55	67
68	67.83	4.74	67.81	5.04	67.79	5.34	67.77	5.63	68
69	68.83	4.81	68.81	5.11	68.79	5.41	68.76	5.71	69
70	69.83	4.88	69.81	5.19	69.78	5.49	69.76	5.80	70
71	70.83	4.95	70.80	5.26	70.78	5.57	70.76	5.88	71
72	71.82	5.02	71.80	5.34	71.78	5.65	71.75	5.96	72
73	72.82	5.09	72.80	5.41	72.77	5.73	72.75	6.04	73
74	73.82	5.16	73.80	5.48	73.77	5.81	73.75	6.13	74
75	74.82	5.23	74.79	5.56	74.77	5.88	74.74	6.21	75
76	75.81	5.30	75.79	5.63	75.77	5.96	75.74	6.29	76
77	76.81	5.37	76.79	5.71	76.76	6.04	76.74	6.38	77
78	77.81	5.44	77.79	5.78	77.76	6.12	77.73	6.46	78
79	78.81	5.51	78.78	5.85	78.76	6.20	78.73	6.54	79
80	79.81	5.58	79.78	5.93	79.75	6.28	79.73	6.62	80
81	80.80	5.65	80.78	6.00	80.75	6.36	80.72	6.71	81
82	81.80	5.72	81.78	6.08	81.75	6.43	81.72	6.79	82
83	82.80	5.79	82.77	6.15	82.74	6.51	82.71	6.87	83
84	83.80	5.86	83.77	6.23	83.74	6.59	83.71	6.96	84
85	84.79	5.93	84.77	6.30	84.74	6.67	84.71	7.04	85
86	85.79	6.00	85.76	6.37	85.73	6.75	85.70	7.12	86
87	86.79	6.07	86.76	6.45	86.73	6.83	86.70	7.20	87
88	87.79	6.14	87.76	6.52	87.73	6.90	87.70	7.29	88
89	88.78	6.21	88.76	6.60	88.73	6.98	88.70	7.37	89
90	89.78	6.28	89.75	6.67	89.72	7.06	89.69	7.45	90
91	90.78	6.35	90.75	6.74	90.72	7.14	90.69	7.54	91
92	91.78	6.42	91.75	6.82	91.72	7.22	91.68	7.62	92
93	92.77	6.49	92.74	6.89	92.71	7.30	92.68	7.70	93
94	93.77	6.56	93.74	6.97	93.71	7.38	93.68	7.78	94
95	94.77	6.63	94.74	7.04	94.71	7.45	94.67	7.87	95
96	95.77	6.70	95.74	7.11	95.70	7.53	95.67	7.95	96
97	96.76	6.77	96.73	7.19	96.70	7.61	96.67	8.03	97
98	97.76	6.84	97.73	7.26	97.70	7.69	97.66	8.12	98
99	98.76	6.91	98.73	7.34	98.69	7.77	98.66	8.20	99
100	99.76	6.98	99.73	7.41	99.69	7.85	99.66	8.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	5 Deg.		5¼ Deg.		5½ Deg.		5¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.09	1.00	0.09	1.00	0.10	0.99	0.10	1
2	1.99	0.17	1.99	0.18	1.99	0.19	1.99	0.20	2
3	2.99	0.26	2.99	0.27	2.99	0.29	2.98	0.30	3
4	3.98	0.35	3.98	0.37	3.98	0.38	3.98	0.40	4
5	4.98	0.44	4.98	0.46	4.98	0.48	4.97	0.50	5
6	5.98	0.52	5.97	0.55	5.97	0.58	5.97	0.60	6
7	6.97	0.61	6.97	0.64	6.97	0.67	6.96	0.70	7
8	7.97	0.70	7.97	0.73	7.96	0.76	7.96	0.80	8
9	8.97	0.78	8.96	0.82	8.96	0.86	8.95	0.90	9
10	9.96	0.87	9.96	0.92	9.95	0.96	9.95	1.00	10
11	10.96	0.96	10.95	1.01	10.95	1.05	10.94	1.10	11
12	11.95	1.05	11.95	1.10	11.94	1.15	11.94	1.20	12
13	12.95	1.13	12.95	1.19	12.94	1.25	12.93	1.30	13
14	13.95	1.22	13.94	1.28	13.94	1.34	13.93	1.40	14
15	14.94	1.31	14.94	1.37	14.93	1.44	14.92	1.50	15
16	15.94	1.39	15.93	1.46	15.93	1.53	15.92	1.60	16
17	16.94	1.48	16.93	1.56	16.92	1.63	16.91	1.70	17
18	17.93	1.57	17.92	1.65	17.92	1.73	17.91	1.80	18
19	18.93	1.66	18.92	1.74	18.91	1.82	18.90	1.90	19
20	19.92	1.74	19.92	1.83	19.91	1.92	19.90	2.00	20
21	20.92	1.83	20.91	1.92	20.90	2.01	20.89	2.10	21
22	21.92	1.92	21.91	2.01	21.90	2.11	21.89	2.20	22
23	22.91	2.00	22.90	2.10	22.89	2.20	22.88	2.30	23
24	23.91	2.09	23.90	2.20	23.89	2.30	23.88	2.40	24
25	24.90	2.18	24.90	2.29	24.88	2.40	24.87	2.50	25
26	25.90	2.27	25.89	2.38	25.88	2.49	25.87	2.60	26
27	26.90	2.35	26.89	2.47	26.88	2.59	26.86	2.71	27
28	27.89	2.44	27.88	2.56	27.87	2.68	27.86	2.81	28
29	28.89	2.53	28.88	2.65	28.87	2.78	28.85	2.91	29
30	29.89	2.61	29.87	2.75	29.86	2.88	29.85	3.01	30
31	30.88	2.70	30.87	2.84	30.86	2.97	30.84	3.11	31
32	31.88	2.79	31.87	2.93	31.85	3.07	31.84	3.21	32
33	32.87	2.88	32.86	3.02	32.85	3.16	32.83	3.31	33
34	33.87	2.96	33.86	3.11	33.84	3.26	33.83	3.41	34
35	34.87	3.05	34.85	3.20	34.84	3.35	34.82	3.51	35
36	35.86	3.14	35.85	3.29	35.83	3.45	35.82	3.61	36
37	36.86	3.22	36.84	3.39	36.83	3.55	36.81	3.71	37
38	37.86	3.31	37.84	3.48	37.83	3.64	37.81	3.81	38
39	38.85	3.40	38.84	3.57	38.82	3.74	38.80	3.91	39
40	39.85	3.49	39.83	3.66	39.82	3.83	39.80	4.01	40
41	40.84	3.57	40.83	3.75	40.81	3.93	40.79	4.11	41
42	41.84	3.66	41.82	3.84	41.81	4.03	41.79	4.21	42
43	42.84	3.75	42.82	3.93	42.80	4.12	42.78	4.31	43
44	43.83	3.83	43.82	4.03	43.80	4.22	43.78	4.41	44
45	44.83	3.92	44.81	4.12	44.79	4.31	44.77	4.51	45
46	45.82	4.01	45.81	4.21	45.79	4.41	45.77	4.61	46
47	46.82	4.10	46.80	4.30	46.78	4.50	46.76	4.71	47
48	47.82	4.18	47.80	4.39	47.78	4.60	47.76	4.81	48
49	48.81	4.27	48.79	4.48	48.77	4.70	48.75	4.91	49
50	49.81	4.36	49.79	4.58	49.77	4.79	49.75	5.01	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg.		

Distance.	5 Deg.		5¼ Deg.		5½ Deg.		5¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.81	4.44	50.79	4.67	50.77	4.89	50.74	5.11	51
52	51.80	4.53	51.78	4.76	51.76	4.98	51.74	5.21	52
53	52.80	4.62	52.78	4.85	52.76	5.08	52.73	5.31	53
54	53.79	4.71	53.77	4.94	53.75	5.18	53.73	5.41	54
55	54.79	4.79	54.77	5.03	54.75	5.27	54.72	5.51	55
56	55.79	4.88	55.77	5.12	55.74	5.37	55.72	5.61	56
57	56.78	4.97	56.76	5.22	56.74	5.46	56.71	5.71	57
58	57.78	5.06	57.76	5.31	57.73	5.56	57.71	5.81	58
59	58.78	5.14	58.75	5.40	58.73	5.65	58.70	5.91	59
60	59.77	5.23	59.75	5.49	59.72	5.75	59.70	6.01	60
61	60.77	5.32	60.74	5.58	60.72	5.85	60.69	6.11	61
62	61.76	5.40	61.74	5.67	61.71	5.94	61.69	6.21	62
63	62.76	5.49	62.74	5.76	62.71	6.04	62.68	6.31	63
64	63.76	5.58	63.73	5.86	63.71	6.13	63.68	6.41	64
65	64.75	5.67	64.73	5.95	64.70	6.23	64.67	6.51	65
66	65.75	5.75	65.72	6.04	65.70	6.33	65.67	6.61	66
67	66.75	5.84	66.72	6.13	66.69	6.42	66.66	6.71	67
68	67.74	5.93	67.71	6.22	67.69	6.52	67.66	6.81	68
69	68.74	6.01	68.71	6.31	68.68	6.61	68.65	6.91	69
70	69.73	6.10	69.71	6.41	69.68	6.71	69.65	7.01	70
71	70.73	6.19	70.70	6.50	70.67	6.81	70.64	7.11	71
72	71.73	6.28	71.70	6.59	71.67	6.90	71.64	7.21	72
73	72.72	6.36	72.69	6.68	72.66	7.00	72.63	7.31	73
74	73.72	6.45	73.69	6.77	73.66	7.09	73.63	7.41	74
75	74.71	6.54	74.69	6.86	74.65	7.19	74.62	7.51	75
76	75.71	6.62	75.68	6.95	75.65	7.28	75.62	7.61	76
77	76.71	6.71	76.68	7.05	76.65	7.38	76.61	7.71	77
78	77.70	6.80	77.67	7.14	77.64	7.48	77.61	7.81	78
79	73.70	6.89	78.67	7.23	78.64	7.57	78.60	7.91	79
80	79.70	6.97	79.66	7.32	79.65	7.67	79.60	8.02	80
81	80.69	7.06	80.66	7.41	80.63	7.76	80.59	8.12	81
82	81.69	7.15	81.66	7.50	81.62	7.86	81.59	8.22	82
83	82.68	7.23	82.65	7.59	82.62	7.96	82.58	8.32	83
84	83.68	7.32	83.65	7.69	83.61	8.05	83.58	8.42	84
85	84.68	7.41	84.64	7.78	84.61	8.15	84.57	8.52	85
86	85.67	7.50	85.64	7.87	85.60	8.24	85.57	8.62	86
87	86.67	7.58	86.64	7.96	86.60	8.34	86.56	8.72	87
88	87.67	7.67	87.63	8.05	87.59	8.43	87.56	8.82	88
89	88.66	7.76	88.63	8.14	88.59	8.53	88.55	8.92	89
90	89.66	7.84	89.62	8.24	89.59	8.63	89.55	9.02	90
91	90.65	7.93	90.62	8.33	90.58	8.72	90.54	9.12	91
92	91.65	8.02	91.61	8.42	91.58	8.82	91.54	9.22	92
93	92.65	8.11	92.61	8.51	92.57	8.91	92.53	9.32	93
94	93.64	8.19	93.61	8.60	93.57	9.01	93.53	9.42	94
95	94.64	8.28	94.60	8.69	94.56	9.11	94.52	9.52	95
96	95.63	8.37	95.60	8.78	95.56	9.20	95.52	9.62	96
97	96.63	8.45	96.59	8.88	96.55	9.30	96.51	9.72	97
98	97.63	8.54	97.59	8.97	97.55	9.39	97.51	9.82	98
99	98.62	8.63	98.59	9.06	98.54	9.49	98.50	9.92	99
100	99.62	8.72	99.58	9.15	99.54	9.58	99.50	10.02	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Distance.
	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg		

Distance.	6 Deg.		6¼ Deg.		6½ Deg.		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.10	0.99	0.11	0.99	0.11	0.99	0.12	1
2	1.99	0.21	1.99	0.22	1.99	0.23	1.99	0.24	2
3	2.98	0.31	2.98	0.33	2.98	0.34	2.98	0.35	3
4	3.98	0.41	3.98	0.44	3.97	0.45	3.97	0.47	4
5	4.97	0.52	4.97	0.54	4.97	0.57	4.97	0.59	5
6	5.97	0.63	5.96	0.65	5.96	0.68	5.36	0.71	6
7	6.96	0.73	6.96	0.76	6.96	0.79	6.95	0.82	7
8	7.96	0.84	7.95	0.87	7.95	0.91	7.94	0.94	8
9	8.95	0.94	8.95	0.98	8.94	1.02	8.94	1.06	9
10	9.95	1.05	9.94	1.09	9.94	1.13	9.93	1.18	10
11	10.94	1.15	10.93	1.20	10.93	1.25	10.92	1.29	11
12	11.93	1.25	11.93	1.31	11.92	1.36	11.92	1.41	12
13	12.93	1.36	12.92	1.42	12.92	1.47	12.91	1.53	13
14	13.92	1.46	13.92	1.52	13.91	1.59	13.90	1.65	14
15	14.92	1.57	14.91	1.63	14.90	1.70	14.90	1.76	15
16	15.91	1.67	15.90	1.74	15.90	1.81	15.89	1.88	16
17	16.91	1.78	16.90	1.85	16.89	1.92	16.88	2.00	17
18	17.90	1.88	17.89	1.96	17.88	2.04	17.88	2.12	18
19	18.90	1.99	18.89	2.07	18.88	2.15	18.87	2.23	19
20	19.89	2.09	19.88	2.18	19.87	2.26	19.86	2.35	20
21	20.88	2.20	20.88	2.29	20.87	2.38	20.85	2.47	21
22	21.88	2.30	21.87	2.40	21.86	2.49	21.85	2.59	22
23	22.87	2.40	22.86	2.50	22.85	2.60	22.84	2.70	23
24	23.87	2.51	23.86	2.61	23.85	2.72	23.83	2.82	24
25	24.86	2.61	24.85	2.72	24.84	2.83	24.83	2.94	25
26	25.86	2.72	25.85	2.83	25.83	2.94	25.82	3.06	26
27	26.85	2.82	26.84	2.94	26.83	3.06	26.81	3.17	27
28	27.85	2.93	27.83	3.05	27.82	3.17	27.81	3.29	28
29	28.84	3.03	28.83	3.16	28.61	3.28	28.80	3.41	29
30	29.84	3.14	29.82	3.27	29.81	3.40	29.79	3.53	30
31	30.83	3.24	30.82	3.37	30.80	3.51	30.79	3.64	31
32	31.82	3.34	31.81	3.48	31.79	3.62	31.78	3.76	32
33	32.82	3.45	32.80	3.59	32.79	3.74	32.77	3.88	33
34	33.81	3.55	33.30	3.70	33.78	3.85	33.76	4.00	34
35	34.81	3.66	34.79	3.81	34.78	3.96	34.76	4.11	35
36	35.80	3.76	35.79	3.92	35.77	4.08	35.75	4.23	36
37	36.80	3.87	36.78	4.03	36.76	4.19	36.75	4.35	37
38	37.79	3.97	37.77	4.14	37.76	4.30	37.74	4.47	38
39	38.79	4.08	38.77	4.25	38.75	4.41	38.73	4.58	39
40	39.78	4.18	39.76	4.35	39.74	4.53	39.72	4.70	40
41	40.78	4.29	40.76	4.46	40.74	4.64	40.72	4.82	41
42	41.77	4.39	41.75	4.57	41.73	4.76	41.71	4.94	42
43	42.76	4.49	42.74	4.68	42.72	4.87	42.70	5.05	43
44	43.76	4.60	43.74	4.79	43.72	4.98	43.70	5.17	44
45	44.75	4.70	44.73	4.90	44.71	5.09	44.69	5.29	45
46	45.75	4.81	45.73	5.01	45.70	5.21	45.68	5.41	46
47	46.74	4.91	46.72	5.12	46.70	5.32	46.67	5.52	47
48	47.74	5.02	47.71	5.23	47.69	5.43	47.67	5.64	48
49	48.73	5.12	48.71	5.34	48.69	5.55	48.66	5.76	49
50	49.73	5.23	49.70	5.44	49.68	5.66	49.65	5.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance.	6 Deg.		6¼ Deg.		6½ Deg		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.72	5.33	50.70	5.55	50.67	5.77	50.65	5.99	51
52	51.72	5.44	51.69	5.66	51.67	5.89	51.64	6.11	52
53	52.71	5.54	52.68	5.77	52.66	6.00	52.63	6.22	53
54	53.70	5.64	53.68	5.88	53.65	6.11	53.63	6.35	54
55	54.70	5.75	54.67	5.99	54.65	6.23	54.62	6.46	55
56	55.69	5.85	55.67	6.10	55.64	6.34	55.61	6.58	56
57	56.69	5.96	56.66	6.21	56.63	6.45	56.60	6.70	57
58	57.68	6.06	57.66	6.31	57.63	6.57	57.60	6.82	58
59	58.68	6.17	58.65	6.42	58.62	6.68	58.59	6.93	59
60	59.67	6.27	59.64	6.53	59.61	6.79	59.58	7.05	60
61	60.67	6.38	60.64	6.64	60.61	6.91	60.58	7.17	61
62	61.66	6.48	61.63	6.75	61.60	7.02	61.57	7.29	62
63	62.65	6.59	62.63	6.86	62.60	7.13	62.56	7.40	63
64	63.65	6.69	63.62	6.97	63.59	7.25	63.56	7.52	64
65	64.64	6.79	64.61	7.08	64.58	7.36	64.55	7.64	65
66	65.64	6.90	65.61	7.19	65.58	7.47	65.54	7.76	66
67	66.63	7.00	66.60	7.29	66.57	7.58	66.54	7.88	67
68	67.63	7.11	67.60	7.40	67.56	7.70	67.53	7.99	68
69	68.62	7.21	68.59	7.51	68.56	7.81	68.52	8.11	69
70	69.62	7.32	69.58	7.62	69.55	7.92	69.51	8.23	70
71	70.61	7.42	70.58	7.73	70.54	8.04	70.51	8.35	71
72	71.61	7.53	71.57	7.84	71.54	8.15	71.50	8.46	72
73	72.60	7.63	72.57	7.95	72.53	8.26	72.49	8.58	73
74	73.59	7.74	73.56	8.06	73.52	8.38	73.49	8.70	74
75	74.59	7.84	74.55	8.17	74.52	8.49	74.48	8.82	75
76	75.58	7.94	75.55	8.27	75.51	8.60	75.47	8.93	76
77	76.58	8.05	76.54	8.38	76.51	8.72	76.47	9.05	77
78	77.57	8.15	77.54	8.49	77.50	8.83	77.46	9.17	78
79	78.57	8.26	78.53	8.60	78.49	8.94	78.45	9.29	79
80	79.56	8.36	79.53	8.71	79.49	9.06	79.45	9.40	80
81	80.56	8.47	80.52	8.82	80.48	9.17	80.44	9.52	81
82	81.55	8.57	81.51	8.93	81.47	9.28	81.43	9.64	82
83	82.55	8.68	82.51	9.04	82.47	9.40	82.42	9.76	83
84	83.54	8.78	83.50	9.14	83.46	9.51	83.42	9.87	84
85	84.53	8.88	84.50	9.25	84.45	9.62	84.41	9.99	85
86	85.53	8.99	85.49	9.36	85.45	9.74	85.40	10.11	86
87	86.52	9.09	86.48	9.47	86.44	9.85	86.40	10.23	87
88	87.52	9.20	87.48	9.58	87.43	9.96	87.39	10.34	88
89	88.51	9.30	88.47	9.69	88.43	10.08	88.38	10.46	89
90	89.51	9.41	89.47	9.80	89.42	10.19	89.38	10.58	90
91	90.50	9.51	90.46	9.91	90.42	10.30	90.37	10.70	91
92	91.50	9.62	91.45	10.02	91.41	10.41	91.36	10.81	92
93	92.49	9.72	92.45	10.12	92.40	10.53	92.36	10.93	93
94	93.49	9.83	93.44	10.23	93.40	10.64	93.35	11.05	94
95	94.48	9.93	94.44	10.34	94.39	10.75	94.34	11.17	95
96	95.47	10.03	95.43	10.45	95.38	10.87	95.33	11.28	96
97	96.47	10.14	96.42	10.56	96.38	10.98	96.33	11.40	97
98	97.46	10.24	97.42	10.67	97.37	11.09	97.32	11.52	98
99	98.46	10.35	98.41	10.78	98.36	11.21	98.31	11.64	99
100	99.45	10.45	99.41	10.89	99.36	11.32	99.31	11.75	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance.	7 Deg.		7¼ Deg.		7½ Deg		7¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.12	0.99	0.13	0.99	0.13	0.99	0.13	1
2	1.99	0.24	1.98	0.25	1.98	0.26	1.98	0.27	2
3	2.98	0.37	2.98	0.38	2.97	0.39	2.97	0.40	3
4	3.97	0.49	3.97	0.50	3.97	0.52	3.96	0.54	4
5	4 96	0.61	4.96	0.63	4.96	0.65	4.95	0.67	5
6	5.96	0.73	5.95	0.76	5.95	0.78	5.95	0.81	6
7	6.95	0.85	6.94	0.88	6.94	0.91	6.94	0.94	7
8	7.94	0.97	7.94	1.01	7.93	1.04	7.93	1.08	8
9	8.93	1.10	8.93	1.14	8.92	1.17	8.92	1.21	9
10	9.93	1.22	9.92	1.26	9.91	1.31	9.91	1.35	10
11	10.92	1.34	10.91	1.39	10.91	1.44	10.90	1.48	11
12	11.91	1.46	11.90	1.51	11.90	1.57	11.89	1.62	12
13	12.90	1.58	12.90	1.64	12.89	1.70	12.88	1.75	13
14	13.90	1.71	13.89	1.77	13.88	1.83	13.87	1.89	14
15	14.89	1.83	14.88	1.89	14.87	1.96	14.86	2.02	15
16	15.88	1.95	15.87	2.02	15.86	2.09	15.85	2.16	16
17	16.87	2.07	16.86	2.15	16.85	2.22	16.84	2.29	17
18	17.87	2.19	17.86	2.27	17.85	2.35	17.84	2.43	18
19	18.86	2.32	18.85	2.40	18.84	2.48	18.83	2.56	19
20	19.85	2.44	19.84	2.52	19.83	2.61	19.82	2.70	20
21	20.84	2.56	20.83	2.65	20.82	2.74	20.81	2.83	21
22	21.84	2.68	21.82	2.78	21.81	2.87	21.80	2.97	22
23	22.83	2.80	22.82	2.90	22.80	3.00	22.79	3.10	23
24	23.82	2.92	23.81	3.03	23.79	3.13	23.78	3.24	24
25	24.81	3.05	24.80	3.15	24.79	3.26	24.77	3.37	25
26	25.81	3.17	25.79	3.28	25.78	3.39	25.76	3.51	26
27	26.80	3.29	26.78	3.41	26.77	3.52	26.75	3.64	27
28	27.79	3.41	27.78	3.53	27.76	3.65	27.74	3.78	28
29	28.78	3.53	28.77	3.66	28.75	3.79	28.74	3.91	29
30	29.78	3.66	29.76	3.79	29.74	3 92	29.73	4.05	30
31	30.77	3.78	30.75	3.91	30.73	4.05	30.72	4.18	31
32	31.76	3.90	31.74	4.04	31.73	4.18	31.71	4.32	32
33	32.75	4.02	32.74	4.16	32.72	4.31	32.70	4.45	33
34	33.75	4.14	33.73	4.29	33.71	4.44	33.69	4.58	34
35	34.74	4.27	34.72	4.42	34.70	4.57	34.68	4.72	35
36	35.73	4.39	35.71	4.54	35.69	4.70	35.67	4.85	36
37	36.72	4.51	36.70	4.67	36.68	4.83	36.66	4.99	37
38	37.72	4.63	37.70	4.80	37.67	4.96	37.65	5.12	38
39	38.71	4.75	38.69	4.92	38.67	5.09	38.64	5.26	39
40	39.70	4.87	39.68	5.05	39.66	5.22	39.63	5.39	40
41	40.70	5.00	40.67	5.17	40.65	5.35	40.63	5.53	41
42	41.69	5.12	41.66	5.30	41.64	5.48	41.62	5.66	42
43	42.68	5.24	42.66	5.43	42.63	5.61	42.61	5.80	43
44	43.67	5.36	43.65	5.55	43.62	5.74	43.60	5.93	44
45	44.67	5.48	44.64	5.68	44.62	5.87	44.59	6.07	45
46	45.66	5.61	45.63	5.81	45.61	6.00	45.58	6.20	46
47	16.65	5.73	46.62	5.93	46.60	6.13	46.57	6.34	47
48	47.64	5.85	47.62	6.06	47.59	6.27	47.56	6.47	48
49	48.63	5.97	48.61	6.18	48.58	6.40	48.55	6.61	49
50	49.63	6.09	49.60	6.31	49.57	6.53	49.54	6.74	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	7 Deg.		7¼ Deg.		7½ Deg.		7¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.62	6.22	50.59	6.44	50.56	6.66	50.53	6.88	51
52	51.61	6.34	51.58	6.56	51.56	6.79	51.53	7.01	52
53	52.60	6.46	52.58	6.69	52.55	6.92	52.52	7.15	53
54	53.60	6.58	53.57	6.81	53.54	7.05	53.51	7.28	54
55	54.59	6.70	54.56	6.94	54.53	7.18	54.50	7.42	55
56	55.58	6.82	55.55	7.07	55.52	7.31	55.49	7.55	56
57	56.58	6.95	56.54	7.19	56.51	7.44	56.48	7.69	57
58	57.57	7.07	57.54	7.32	57.50	7.57	57.47	7.82	58
59	58.56	7.19	58.53	7.45	58.50	7.70	58.46	7.96	59
60	59.55	7.31	59.52	7.57	59.49	7.83	59.45	8.09	60
61	60.55	7.43	60.51	7.70	60.48	7.96	60.44	8.23	61
62	61.54	7.56	61.50	7.82	61.47	8.09	61.43	8.36	62
63	62.53	7.68	62.50	7.95	62.46	8.22	62.42	8.50	63
64	63.52	7.80	63.49	8.08	63.45	8.35	63.42	8.63	64
65	64.52	7.92	64.48	8.20	64.44	8.48	64.41	8.77	65
66	65.51	8.04	65.47	8.33	65.44	8.61	65.40	8.90	66
67	66.50	8.17	66.46	8.46	66.43	8.75	66.39	9.04	67
68	67.49	8.29	67.46	8.58	67.42	8.88	67.38	9.17	68
69	68.49	8.41	68.45	8.71	68.41	9.01	68.37	9.30	69
70	69.48	8.53	69.44	8.83	69.40	9.14	69.36	9.44	70
71	70.47	8.65	70.43	8.96	70.39	9.27	70.35	9.57	71
72	71.46	8.77	71.42	9.09	71.38	9.40	71.34	9.71	72
73	72.46	8.90	72.42	9.21	72.38	9.53	72.33	9.84	73
74	73.45	9.82	73.41	9.34	73.37	9.66	73.32	9.98	74
75	74.44	9.14	74.40	9.46	74.36	9.79	74.31	10.11	75
76	75.43	9.26	75.39	9.59	75.35	9.92	75.31	10.25	76
77	76.43	9.38	76.38	9.72	76.34	10.05	76.30	10.38	77
78	77.42	9.51	77.38	9.84	77.33	10.18	77.29	10.52	78
79	78.41	9.63	78.37	9.97	78.32	10.31	78.28	10.65	79
80	79.40	9.75	79.36	10.10	79.32	10.44	79.27	10.79	80
81	80.40	9.87	80.35	10.22	80.31	10.57	80.26	10.92	81
82	81.39	9.99	81.34	10.35	81.30	10.70	81.25	11.06	82
83	82.38	10.12	82.34	10.47	82.29	10.83	82.24	11.19	83
84	83.37	10.24	83.33	10.60	83.28	10.96	83.23	11.33	84
85	84.37	10.36	84.32	10.73	84.27	11.09	84.22	11.46	85
86	85.36	10.48	85.31	10.85	85.26	11.23	85.21	11.60	86
87	86.35	10.60	86.30	10.98	86.26	11.36	86.21	11.73	87
88	87.34	10.72	87.30	11.11	87.25	11.49	87.20	11.87	88
89	88.34	10.85	88.29	11.23	88.24	11.62	88.19	12.00	89
90	89.33	10.97	89.28	11.36	89.23	11.75	89.18	12.14	90
91	90.32	11.09	90.27	11.48	90.22	11.88	90.17	12.27	91
92	91.31	11.21	91.26	11.61	91.21	12.01	91.16	12.41	92
93	92.31	11.33	92.26	11.74	92.20	12.14	92.15	12.54	93
94	93.30	11.46	93.25	11.86	93.20	12.27	93.14	12.68	94
95	94.29	11.58	94.24	11.99	94.19	12.40	94.13	12.81	95
96	95.28	11.70	95.23	12.12	95.18	12.53	95.12	12.95	96
97	96.28	11.82	96.22	12.24	96.17	12.66	96.11	13.08	97
98	97.27	11.94	97.22	12.37	97.16	12.79	97.10	13.22	98
99	98.26	12.07	98.21	12.49	98.15	12.92	98.10	13.35	99
100	99.25	12.19	99.20	12.62	99.14	13.05	99.09	13.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.14	0.99	0.14	0.99	0.15	0.99	0.15	1
2	1.98	0.28	1.98	0.29	1.93	0.30	1.98	0.30	2
3	2.97	0.42	2.97	0.43	2.97	0.44	2.97	0.46	3
4	3.96	0.56	3.96	0.57	3.96	0.59	3.95	0.61	4
5	4.95	0.70	4.95	0.72	4.95	0.74	4.94	0.76	5
6	5.94	0.84	5.94	0.86	5.93	0.89	5.93	0.91	6
7	6.93	0.97	6.93	1.00	6.92	1.03	6.92	1.06	7
8	7.92	1.11	7.92	1.15	7.91	1.18	7.91	1 22	8
9	8.91	1.25	8.91	1.29	8.90	1.33	8.90	1.37	9
10	9.90	1.39	9.90	1.43	9.89	1.48	9.88	1.52	10
11	10.89	1.53	10.89	1.58	10.88	1.63	10.87	1.67	11
12	11.88	1.67	11.88	1.72	11.87	1.77	11.86	1.83	12
13	12.87	1.81	12.87	1.87	12.86	1.92	12.85	1.98	13
14	13.86	1.95	13.86	2.01	13.85	2.07	13.84	2.13	14
15	14.85	2.09	14.85	2.15	14.84	2.22	14.83	2.28	15
16	15.84	2.23	15.84	2.30	15.82	2.36	15.81	2.43	16
17	16.83	2.37	16.83	2.44	16.81	2.51	16.80	2.59	17
18	17.82	2.51	17.81	2.58	17.80	2.66	17.79	2.74	18
19	18.82	2.64	18.80	2.73	18.79	2.81	18.78	2.89	19
20	19.81	2.78	19.79	2.87	19.78	2.96	19.77	3.04	20
21	20.80	2.92	20.78	3.01	20.77	3.10	20.76	3.19	21
22	21.79	3.06	21.77	3.16	21.76	3.25	21.74	3.35	22
23	22.78	3.20	22.76	3.30	22.75	3.40	22.73	3.50	23
24	23.77	3.34	23.75	3.44	23.74	3.55	23.72	3.65	24
25	24.76	3.48	24.74	3.59	24.73	3.70	24.71	3.80	25
26	25.75	3.62	25.73	3.73	25.71	3.84	25.70	3.96	26
27	26.74	3.76	26.72	3.87	26.70	3.99	26.69	4.11	27
28	27.73	3.90	27.71	4.02	27.69	4.14	27.67	4.26	28
29	28.72	4.04	28.70	4.16	28.68	4.29	28.66	4.41	29
30	29.71	4.18	29.69	4.30	29.67	4.43	29.65	4.56	30
31	30.70	4.31	30.68	4.45	30.66	4.58	30.64	4.72	31
32	31.69	4.45	31.67	4.59	31.65	4.73	31.63	4.87	32
33	32.68	4.59	32.66	4.74	32.64	4.88	32.62	5.02	33
34	33.67	4.73	33.65	4.88	33.63	5.03	33.60	5.17	34
35	34.66	4.87	34.64	5.02	34.62	5.17	34.59	5.32	35
36	35.65	5.01	35.63	5.17	35.60	5.32	35.58	5.48	36
37	36.64	5.15	36.62	5.31	36.59	5.47	36.57	5.63	37
38	37.63	5.29	37.61	5.45	37.58	5.62	37.56	5.78	38
39	38.62	5.43	38.60	5.60	38.57	5.76	38.55	5.93	39
40	39.61	5.57	39·59	5.74	39.56	5.91	39.53	6.08	40
41	40.60	5.71	40.58	5.88	40.55	6.06	40.52	6.24	41
42	41.59	5.85	41.57	6.03	41.54	6.21	41.51	6.39	42
43	42.58	5.98	42.56	6.17	42.53	6.36	42.50	6.54	43
44	43.57	6.12	43.54	6.31	43.52	6.50	43.49	6.69	44
45	44.56	6.26	44.53	6.46	44.51	6.65	44.48	6.85	45
46	45.55	6.40	45.52	6.60	45.49	6.80	45.46	7.00	46
47	46.54	6.54	46.5	6.74	46.48	6.95	46.45	7.15	47
48	47.53	6.68	47.50	6.89	47.47	7.09	47.44	7.30	48
49	48.52	6.82	48.49	7.03	48.46	7.24	48.43	7.45	49
50	49.51	6.96	49.48	7.17	49.45	7.39	49.42	7.61	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.50	7.10	50.47	7.32	50.44	7.54	50.41	7.76	51
52	51.49	7.24	51.46	7.46	51.43	7.69	51.39	7.91	52
53	52.48	7.38	52.45	7.61	52.42	7.83	52.38	8.06	53
54	53.47	7.52	53.44	7.75	53.41	7.98	53.37	8.21	54
55	54.46	7.65	54.43	7.89	54.40	8.13	54.36	8.37	55
56	55.46	7.79	55.42	8.04	55.38	8.28	55.35	8.52	56
57	56.45	7.93	56.41	8.18	56.37	8.43	56.34	8.67	57
58	57.44	8.07	57.40	8.32	57.36	8.57	57.32	8.82	58
59	58.43	8.21	58.39	8.47	58.35	8.72	58.31	8.98	59
60	59.42	8.35	59.38	8.61	59.34	8.87	59.30	9.13	60
61	60.41	8.49	60.37	8.75	60.33	9.02	60.29	9.28	61
62	61.40	8.63	61.36	8.90	61.32	9.16	61.28	9.43	62
63	62.39	8.77	62.35	9.04	62.31	9.31	62.27	9.58	63
64	63.38	8.91	63.34	9.18	63.30	9.46	63.26	9.74	64
65	64.37	9.05	64.33	9.33	64.29	9.61	64.24	9.89	65
66	65.36	9.19	65.32	9.47	65.28	9.76	65.23	10.04	66
67	66.35	9.32	66.31	9.61	66.26	9.90	66.22	10.19	67
68	67.34	9.46	67.30	9.76	67.25	10.05	67.21	10.34	68
69	68.33	9.60	68.29	9.90	68.24	10.20	68.20	10.50	69
70	69.32	9.74	69.28	10.04	69.23	10.35	69.19	10.65	70
71	70.31	9.88	70.27	10.19	70.22	10.49	70.17	10.80	71
72	71.30	10.02	71.25	10.33	71.21	10.64	71.16	10.95	72
73	72.29	10.16	72.24	10.47	72.20	10.79	72.15	11.10	73
74	73.28	10.30	73.23	10.62	73.19	10.94	73.14	11.26	74
75	74.27	10.44	74.22	10.76	74.18	11.09	74.13	11.41	75
76	75.26	10.58	75.21	10.91	75.17	11.23	75.12	11.56	76
77	76.25	10.72	76.20	11.05	76.15	11.38	76.10	11.71	77
78	77.24	10.86	77.19	11.19	77.14	11.53	77.09	11.87	78
79	78.23	10.99	78.18	11.34	78.13	11.68	78.08	12.02	79
80	79.22	11.13	79.17	11.48	79.12	11.82	79.07	12.17	80
81	80.21	11.27	80.16	11.62	80.11	11.97	80.06	12.32	81
82	81.20	11.41	81.15	11.77	81.10	12.12	81.05	12.47	82
83	82.19	11.55	82.14	11.91	82.09	12.27	82.03	12.63	83
84	83.18	11.69	83.13	12.05	83.08	12.42	83.02	12.78	84
85	84.17	11.83	84.12	12.20	84.07	12.56	84.01	12.93	85
86	85.16	11.97	85.11	12.34	85.06	12.71	85.00	13.08	86
87	86.15	12.11	86.10	12.48	86.04	12.86	85.99	13.23	87
88	87.14	12.25	87.09	12.63	87.03	13.01	86.98	13.39	88
89	88.13	12.39	88.08	12.77	88.02	13.16	87.96	13.54	89
90	89.12	12.53	89.07	12.91	89.01	13.30	88.95	13.69	90
91	90.11	12.66	90.06	13.06	90.00	13.45	89.94	13.84	91
92	91.10	12.80	91.05	13.20	90.99	13.60	90.93	14.00	92
93	92.09	12.94	92.04	13.34	91.98	13.75	91.92	14.15	93
94	93.09	13.08	93.03	13.49	92.97	13.89	92.91	14.30	94
95	94.08	13.22	94.02	13.63	93.96	14.04	93.89	14.45	95
96	95.07	13.36	95.01	13.78	94.95	14.19	94.88	14.60	96
97	96.06	13.50	96.00	13.92	95.93	14.34	95.87	14.76	97
98	97.05	13.64	96.99	14.06	96.92	14.49	96.86	14.91	98
99	98.04	13.78	97.98	14.21	97.91	14.63	97.85	15.06	99
100	99.03	13.92	98.97	14.35	98.90	14.78	98.84	15.21	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		

Distance.	9 Deg.		9¼ Deg.		9½ Deg		9¾ Deg		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.16	0.99	0.16	0.99	0.17	0.99	0.17	1
2	1.98	0.31	1.97	0.32	1.97	0.33	1.97	0.34	2
3	2.96	0.47	2.96	0.48	2.96	0.50	2.96	0.51	3
4	3.95	0.63	3.95	0.64	3.95	0.66	3.94	0.68	4
5	4.94	0.78	4.93	0.80	4.93	0.83	4.93	0.85	5
6	5.93	0.94	5.92	0.96	5.92	0.99	5.91	1.02	6
7	6.91	1.10	6.91	1.13	6.90	1.16	6.90	1.19	7
8	7.90	1.25	7.90	1.29	7.89	1.32	7.88	1.35	8
9	8.89	1.41	8.88	1.45	8.88	1.49	8.87	1.52	9
10	9.88	1.56	9.87	1.61	9.86	1.65	9.86	1.69	10
11	10.86	1.72	10.86	1.77	10.85	1.82	10.84	1.86	11
12	11.85	1.88	11.84	1.93	11.84	1.98	11.83	2.03	12
13	12.84	2.03	12.83	2.09	12.82	2.15	12.81	2.20	13
14	13.83	2.19	13.82	2.25	13.81	2.31	13.80	2.37	14
15	14.82	2.35	14.80	2.41	14.79	2.48	14.78	2.54	15
16	15.80	2.50	15.79	2.57	15.78	2.64	15.77	2.71	16
17	16.79	2.66	16.78	2.73	16.77	2.81	16.75	2.88	17
18	17.78	2.82	17.77	2.89	17.75	2.97	17.74	3.05	18
19	18.77	2.97	18.75	3.05	18.74	3.14	18.73	3.22	19
20	19.75	3.13	19.74	3.21	19.73	3.30	19.71	3.39	20
21	20.74	3.29	20.73	3.38	20.71	3.47	20.70	3.56	21
22	21.73	3.44	21.71	3.54	21.70	3.63	21.68	3.73	22
23	22.72	3.60	22.70	3.70	22.68	3.80	22.67	3.90	23
24	23.70	3.75	23.69	3.86	23.67	3.96	23.65	4.06	24
25	24.69	3.91	24.67	4.02	24.66	4.13	24.64	4.23	25
26	25.68	4.07	25.66	4.18	25.64	4.29	25.62	4.40	26
27	26.67	4.22	26.65	4.34	26.63	4.46	26.61	4.57	27
28	27.66	4.38	27.64	4.50	27.62	4.62	27.60	4.74	28
29	28.64	4.54	28.62	4.66	28.60	4.79	28.58	4.91	29
30	29.63	4.69	29.61	4.82	29.59	4.95	29.57	5.08	30
31	30.62	4.85	30.60	4.98	30.57	5.12	30.55	5.25	31
32	31.61	5.01	31.58	5.14	31.56	5.28	31.54	5.42	32
33	32.59	5.16	32.57	5.30	32.55	5.45	32.52	5.59	33
34	33.58	5.32	33.56	5.47	33.53	5.61	33.51	5.76	34
35	34.57	5.48	34.54	5.63	34.52	5.78	34.49	5.93	35
36	35.56	5.63	35.53	5.79	35.51	5.94	35.48	6.10	36
37	36.54	5.79	36.52	5.95	36.49	6.11	36.47	6.27	37
38	37.53	5.94	37.51	6.11	37.48	6.27	37.45	6.44	38
39	38.52	6.10	38.49	6.27	38.47	6.44	38.44	6.60	39
40	39.51	6.26	39.48	6.43	39.45	6.60	39.42	6.77	40
41	40.50	6.41	40.47	6.59	40.44	6.77	40.41	6.94	41
42	41.48	6.57	41.45	6.75	41.42	6.92	41.39	7.11	42
43	42.47	6.73	42.44	6.91	42.41	7.10	42.38	7.28	43
44	43.46	6.88	43.43	7.07	43.40	7.26	43.36	7.45	44
45	44.45	7.04	44.41	7.23	44.38	7.43	44.35	7.62	45
46	45.43	7.20	45.40	7.39	45.37	7.59	45.34	7.79	46
47	46.42	7.35	46.39	7.55	46.36	7.76	46.32	7.96	47
48	47.41	7.51	47.38	7.72	47.34	7.92	47.31	8.13	48
49	48.40	7.67	48.36	7.88	48.33	8.09	48.29	8.30	49
50	49.38	7.82	49.35	8.04	49.32	8.25	49.28	8.47	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	9 Deg.		9¼ Deg		9½ Deg.		9¾ Deg		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.37	7.98	50.34	8.20	50.30	8.42	50.26	8.61	51
52	51.36	8.13	51.32	8.36	51.29	8.58	51.25	8.81	52
53	52.35	8.29	52.31	8.52	52.27	8.75	52.23	8.98	53
54	53.34	8.45	53.30	8.68	53.26	8.91	53.22	9.14	54
55	54.32	8.60	54.28	8.84	54.25	9.08	54.21	9.31	55
56	55.31	8.76	55.27	9.00	55.23	9.24	55.19	9.48	56
57	56.30	8.92	56.26	9.16	56.22	9.41	56.18	9.65	57
58	57.29	9.07	57.25	9.32	57.20	9.57	57.16	9.82	58
59	58.27	9.23	58.23	9.48	58.19	9.74	58.15	9.99	59
60	59.26	9.39	59.22	9.64	59.18	9.90	59.13	10.16	60
61	60.25	9.54	60.21	9.81	60.16	10.07	60.12	10.33	61
62	61.24	9.70	61.19	9.97	61.15	10.23	61.10	10.50	62
63	62.22	9.86	62.18	10.13	62.14	10.40	62.09	10.67	63
64	63.21	10.01	63.17	10.29	63.12	10.56	63.08	10.84	64
65	64.20	10.17	64.15	10.45	64.11	10.73	64.06	11.01	65
66	65.19	10.32	65.14	10.61	65.09	10.89	65.05	11.18	66
67	66.18	10.48	66.13	10.77	66.08	11.06	66.03	11.35	67
68	67.16	10.64	67.12	10.93	67.07	11.22	67.02	11.52	68
69	68.15	10.79	68.10	11.09	68.05	11.39	68.00	11.69	69
70	69.14	10.95	69.09	11.25	69.04	11.55	68.99	11.85	70
71	70.13	11.11	70.08	11.41	70.03	11.72	69.97	12.02	71
72	71.11	11.26	71.06	11.57	71.01	11.88	70.96	12.19	72
73	72.10	11.42	72.05	11.73	72.00	12.05	71.95	12.36	73
74	73.09	11.58	73.04	11.89	72.99	12.21	72.93	12.53	74
75	74.08	11.73	74.02	12.06	73.97	12.38	73.92	12.70	75
76	75.06	11.89	75.01	12.22	74.96	12.54	74.90	12.87	76
77	76.05	12.05	76.00	12.38	75.94	12.71	75.89	13.04	77
78	77.04	12.20	76.99	12.54	76.93	12.87	76.87	13.21	78
79	78.03	12.36	77.97	12.70	77.92	13.04	77.86	13.38	79
80	79.02	12.51	78.96	12.86	78.90	13.20	78.84	13.55	80
81	80.00	12.67	79.95	13.02	79.89	13.37	79.83	13.72	81
82	80.99	12.83	80.93	13.18	80.88	13.53	80.82	13.89	82
83	81.98	12.98	81.92	13.34	81.86	13.70	81.80	14.06	83
84	82.97	13.14	82.91	13.50	82.85	13.86	82.79	14.23	84
85	83.95	13.30	83.89	13.66	83.83	14.03	83.77	14.39	85
86	84.94	13.45	84.88	13.82	84.82	14.19	84.76	14.56	86
87	85.93	13.61	85.87	13.98	85.81	14.36	85.74	14.73	87
88	86.92	13.77	86.86	14.15	86.79	14.52	86.73	14.90	88
89	87.90	13.92	87.84	14.31	87.78	14.69	87.71	15.07	89
90	88.89	14.08	88.83	14.47	88.77	14.85	88.70	15.24	90
91	89.88	14.24	89.82	14.63	89.75	15.02	89.69	15.41	91
92	90.87	14.39	90.80	14.79	90.74	15.18	90.67	15.58	92
93	91.86	14.55	91.79	14.95	91.72	15.35	91.66	15.75	93
94	92.84	14.70	92.78	15.11	92.71	15.51	92.64	15.92	94
95	93.83	14.86	93.76	15.27	93.70	15.68	93.63	16.09	95
96	94.82	15.02	94.75	15.43	94.68	15.84	94.61	16.26	96
97	95.81	15.17	95.74	15.59	95.67	16.01	95.60	16.43	97
98	96.79	15.33	96.73	15.75	96.66	16.17	96.58	16.60	98
99	97.78	15.49	97.71	15.91	97.64	16.34	97.57	16.77	99
100	98.77	15.64	98.70	16.07	98.63	16.50	98.56	16.93	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	10 Deg.		10¼ Deg.		10½ Deg.		10¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.17	0.98	0.18	0.98	0.18	0.98	0.19	1
2	1.97	0.35	1.97	0.36	1.97	0.36	1.96	0.37	2
3	2.95	0.52	2.95	0.53	2.95	0.55	2.95	0.56	3
4	3.94	0.69	3.94	0.71	3.93	0.73	3.93	0.75	4
5	4.92	0.87	4.92	0.89	4.92	0.91	4.91	0.93	5
6	5.91	1.04	5.90	1.07	5.90	1.09	5.89	1.12	6
7	6.89	1.22	6.89	1.25	6.88	1.28	6.88	1.31	7
8	7.88	1.39	7.87	1.42	7.87	1.46	7.86	1.49	8
9	8.86	1.56	8.86	1.60	8.85	1.64	8.84	1.68	9
10	9.85	1.74	9.84	1.78	9.83	1.82	9.82	1.87	10
11	10.83	1.91	10.82	1.96	10.82	2.00	10.81	2.05	11
12	11.82	2.08	11.81	2.14	11.80	2.19	11.79	2.24	12
13	12.80	2.26	12.79	2.31	12.78	2.37	12.77	2.42	13
14	13.79	2.43	13.78	2.49	13.77	2.55	13.75	2.61	14
15	14.77	2.60	14.76	2.67	14.75	2.73	14.74	2.80	15
16	15.76	2.78	15.74	2.85	15.73	2.92	15.72	2.98	16
17	16.74	2.95	16.73	3.03	16.72	3.10	16.70	3.17	17
18	17.73	3.13	17.71	3.20	17.70	3.28	17.68	3.36	18
19	18.71	3.30	18.70	3.38	18.68	3.46	18.67	3.54	19
20	19.70	3.47	19.68	3.56	19.67	3.64	19.65	3.73	20
21	20.68	3.65	20.66	3.74	20.65	3.83	20.63	3.92	21
22	21.67	3.82	21.65	3.91	21.63	4.01	21.61	4.10	22
23	22.65	3.99	22.63	4.09	22.61	4.19	22.60	4.29	23
24	23.64	4.17	23.62	4.27	23.60	4.37	23.58	4.48	24
25	24.62	4.34	24.60	4.45	24.58	4.56	24.56	4.66	25
26	25.61	4.51	25.59	4.63	25.56	4.74	25.54	4.85	26
27	26.59	4.69	26.57	4.80	26.55	4.92	26.53	5.04	27
28	27.57	4.86	27.55	4.98	27.53	5.10	27.51	5.22	28
29	28.56	5.04	28.54	5.16	28.51	5.28	28.49	5.41	29
30	29.54	5.21	29.52	5.34	29.50	5.47	29.47	5.60	30
31	30.53	5.38	30.51	5.52	30.48	5.65	30.46	5.78	31
32	31.51	5.56	31.49	5.69	31.46	5.83	31.44	5.97	32
33	32.50	5.73	32.47	5.87	32.45	6.01	32.42	6.16	33
34	33.48	5.90	33.46	6.05	33.43	6.20	33.40	6.34	34
35	34.47	6.08	34.44	6.23	34.41	6.38	34.39	6.53	35
36	35.45	6.25	35.43	6.41	35.40	6.56	35.37	6.71	36
37	36.44	6.42	36.41	6.58	36.38	6.74	36.35	6.90	37
38	37.42	6.60	37.39	6.76	37.36	6.92	37.33	7.09	38
39	38.41	6.77	38.38	6.94	38.35	7.11	38.32	7.27	39
40	39.39	6.95	39.36	7.12	39.33	7.29	39.30	7.46	40
41	40.38	7.12	40.35	7.30	40.31	7.47	40.28	7.65	41
42	41.36	7.29	41.33	7.47	41.30	7.65	41.26	7.83	42
43	42.35	7.47	42.31	7.65	42.28	7.84	42.25	8.02	43
44	43.33	7.64	43.30	7.83	43.26	8.02	43.23	8.21	44
45	44.32	7.81	44.28	8.01	44.25	8.20	44.21	8.39	45
46	45.30	7.99	45.27	8.19	45.23	8.38	45.19	8.58	46
47	46.29	8.16	46.25	8.36	46.21	8.57	46.18	8.77	47
48	47.27	8.34	47.23	8.54	47.20	8.75	47.16	8.95	48
49	48.26	8.51	48.22	8.72	48.18	8.93	48.14	9.14	49
50	49.24	8.68	49.20	8.90	49.16	9.11	49.12	9.33	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	80 Deg.		79¾ Deg.		79½ Deg.		79¼ Deg.		

Distance.	10 Deg.		10¼ Deg.		10½ Deg.		10¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.23	8.86	50.19	9.08	50.15	9.29	50.10	9.51	51
52	51.21	9.03	51.17	9.25	51.13	9.48	51.09	9 70	52
53	52.19	9.20	52.15	9.43	52.11	9.66	52.07	9.89	53
54	53.18	9.38	53.14	9.61	53.10	9.84	53.05	10.07	54
55	54.16	9.55	54.12	9.79	54.08	10.02	54.03	10.26	55
56	55.15	9.72	55.11	9.96	55.06	10.21	55.02	10.45	56
57	56.13	9.90	56.09	10.14	56.05	10.39	56.00	10.63	57
58	57.12	10.07	57.07	10.32	57.03	10.57	56.98	10.82	58
59	58.10	10.25	58.06	10.50	58.01	10.75	57.96	11.00	59
60	59.09	10.42	59.04	10.68	59.00	10.93	58.95	11.19	60
61	60.07	10.59	60.03	10.85	59.98	11.12	59.93	11.38	61
62	61.06	10.77	61.01	11.03	60.96	11.30	60.91	11.56	62
63	62.04	10.94	61.99	11.21	61.95	11.48	61.89	11.75	63
64	63.03	11.11	62.98	11.39	62.93	11.66	62.88	11.94	64
65	64.01	11.29	63.96	11.57	63.91	11.85	63.86	12.12	65
66	65.00	11.46	64.95	11.74	64.89	12.03	64.84	12.31	66
67	65.98	11.63	65.93	11.92	65.88	12.21	65.82	12.50	67
68	66.97	11.81	66.91	12.10	66.86	12.39	66.81	12.68	68
69	67.95	11.98	67.90	12.28	67.84	12.57	67.79	12.87	69
70	68.94	12.16	68.88	12.46	68.83	12.76	68.77	13.06	70
71	69.92	12.33	69.87	12.63	69.81	12.94	69.75	13.24	71
72	70.91	12.50	70.85	12.81	70.79	13.12	70.74	13.43	72
73	71.89	12.68	71.83	12.99	71.78	13.30	71.72	13.62	73
74	72.88	12.85	72.82	13.17	72.76	13.49	72.70	13.80	74
75	73.86	13.02	73.80	13.35	73.74	13.67	73.68	13.99	75
76	74.85	13.20	74.79	13.52	74.73	13.85	74.67	14.18	76
77	75.83	13.37	75.77	13.70	75.71	14.03	75.65	14.36	77
78	76.82	13.54	76.76	13.88	76.69	14.21	76.63	14.55	78
79	77.80	13.72	77.74	14.06	77.68	14.40	77.61	14.74	79
80	78.78	13.89	78.72	14.24	78.66	14.58	78.60	14.92	80
81	79.77	14.07	79.71	14.41	79.64	14.76	79.58	15.11	81
82	80.75	14.24	80.69	14.59	80.63	14.94	80.56	15.29	82
83	81.74	14.41	81.68	14.77	81.61	15.13	81.54	15.48	83
84	82.72	14.59	82.66	14.95	82.59	15.31	82.53	15.67	84
85	83.71	14.76	83.64	15.13	83.58	15.49	83.51	15.85	85
86	84.69	14.93	84.63	15.30	84.56	15.67	84.49	16.04	86
87	85.68	15.11	85.61	15.48	85.54	15.85	85.47	16.23	87
88	86.66	15.28	86.60	15.66	86.53	16.04	86.46	16.41	88
89	87.65	15.45	87.58	15.84	87.51	16.22	87.44	16.60	89
90	88.63	15.63	88.56	16.01	88.49	16.40	88.42	16.79	90
91	89.62	15.80	89.55	16.19	89.48	16.58	89.40	16.97	91
92	90.60	15.98	90.53	16.37	90.46	16.77	90.39	17.16	92
93	91.59	16.15	91.52	16.55	91.44	16.95	91.37	17.35	93
94	92.57	16.32	92.50	16.73	92.43	17.13	92.35	17.53	94
95	93.56	16.50	93.48	16.90	93.41	17.31	93.33	17.72	95
96	94.54	16.67	94.47	17.08	94.39	17.49	94.32	17.91	96
97	95.53	16.84	95.45	17.26	95.38	17.68	95.30	18.09	97
98	96.51	17.02	96.44	17.44	96.36	17.86	96.28	18.28	98
99	97.50	17.19	97.42	17.62	97.34	18.04	97.26	18.47	99
100	98.48	17.36	98.40	17.79	98.33	18.22	98.25	18.65	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	80 Deg.		79¾ Deg.		79½ Deg.		79¼ Deg.		

Distance.	11 Deg.		11¼ Deg.		11½ Deg.		11¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.19	0.98	0.20	0.98	0.20	0.98	0.20	1
2	1.96	0.38	1.96	0.39	1.96	0.40	1.96	0.41	2
3	2.94	0.57	2.94	0.59	2.94	0.60	2.94	0.61	3
4	3.93	0.76	3.92	0.78	3.92	0.80	3.92	0.82	4
5	4.91	0.95	4.90	0.98	4.90	1.00	4.90	1.02	5
6	5.89	1.14	5.88	1.17	5.88	1.20	5.87	1.22	6
7	6.87	1.34	6.87	1.37	6.86	1.40	6.85	1.43	7
8	7.85	1.53	7.85	1.56	7.84	1.59	7.83	1.63	8
9	8.83	1.72	8.83	1.76	8.82	1.79	8.81	1.83	9
10	9.82	1.91	9.81	1.95	9.80	1.99	9.79	2.04	10
11	10.80	2.10	10.79	2.15	10.78	2.19	10.77	2.24	11
12	11.78	2.29	11.77	2.34	11.76	2.39	11.75	2.44	12
13	12.76	2.48	12.75	2.54	12.74	2.59	12.73	2.65	13
14	13.74	2.67	13.73	2.73	13.72	2.79	13.71	2.85	14
15	14.72	2.86	14.71	2.93	14.70	2.99	14.69	3.06	15
16	15.71	3.05	15.69	3.12	15.68	3.19	15.66	3.26	16
17	16.69	3.24	16.67	3.32	16.66	3.39	16.64	3.46	17
18	17.67	3.43	17.65	3.51	17.64	3.59	17.62	3.66	18
19	18.65	3.63	18.63	3.71	18.62	3.79	18.60	3.87	19
20	19.63	3.82	19.62	3.90	19.60	3.99	19.58	4.07	20
21	20.61	4.01	20.60	4.10	20.58	4.19	20.56	4.28	21
22	21.60	4.20	21.58	4.29	21.56	4.39	21.54	4.48	22
23	22.58	4.39	22.56	4.49	22.54	4.59	22.52	4.68	23
24	23.56	4.58	23.54	4.68	23.52	4.78	23.50	4.89	24
25	24.54	4.77	24.52	4.88	24.50	4.98	24.48	5.09	25
26	25.52	4.96	25.50	5.07	25.48	5.18	25.46	5.30	26
27	26.50	5.15	26.48	5.27	26.46	5.38	26.43	5.50	27
28	27.49	5.34	27.46	5.46	27.44	5.58	27.41	5.70	28
29	28.47	5.53	28.44	5.66	28.42	5.78	28.39	5.91	29
30	29.45	5.72	29.42	5.85	29.40	5.98	29.37	6.11	30
31	30.43	5.92	30.40	6.05	30.38	6.18	30.35	6.31	31
32	31.41	6.11	31.39	6.24	31.36	6.38	31.33	6.52	32
33	32.39	6.30	32.37	6.44	32.34	6.58	32.31	6.72	33
34	33.38	6.49	33.35	6.63	33.32	6.78	33.29	6.92	34
35	34.36	6.68	34.33	6.83	34.30	6.98	34.27	7.13	35
36	35.34	6.87	35.31	7.02	35.28	7.18	35.25	7.33	36
37	36.32	7.06	36.29	7.22	36.26	7.38	36.22	7.53	37
38	37.30	7.25	37.27	7.41	37.24	7.58	37.20	7.74	38
39	38.28	7.44	38.25	7.61	38.22	7.78	38.18	7.94	39
40	39.27	7.63	39.23	7.80	39.20	7.97	39.16	8.15	40
41	40.25	7.82	40.21	8.00	40.18	8.17	40.14	8.35	41
42	41.23	8.01	41.19	8.19	41.16	8.37	41.12	8.55	42
43	42.21	8.20	42.17	8.39	42.14	8.57	42.10	8.76	43
44	43.19	8.40	43.15	8.58	43.12	8.77	43.08	8.96	44
45	44.17	8.59	44.14	8.78	44.10	8.97	44.06	9.16	45
46	45.15	8.78	45.12	8.97	45.08	9.17	45.04	9.37	46
47	46.14	8.97	46.10	9.17	46.06	9.37	46.02	9.57	47
48	47.12	9.16	47.08	9.36	47.04	9.57	46.99	9.78	48
49	48.10	9.35	48.06	9.56	48.02	9.77	47.97	9.98	49
50	49.08	9.54	49.04	9.75	49.00	9.97	48.95	10.18	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		

Distance	11 Deg.		11¼ Deg.		11½ Deg.		11¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.06	9.73	50.02	9.95	49.98	10.17	49.93	10.39	51
52	51.04	9.92	51.00	10.14	50.96	10.37	50.91	10.59	52
53	52.03	10.11	51.98	10.34	51.94	10.57	51.89	10.79	53
54	53.01	10.30	52.96	10.53	52.92	10.77	52.87	11.00	54
55	53.99	10.49	53.94	10.73	53.90	10.97	53.85	11.20	55
56	54.97	10.69	54.92	10.93	54.88	11.16	54.83	11.40	56
57	55.95	10.88	55.90	11.12	55.86	11.36	55.81	11.61	57
58	56.93	11.07	56.89	11.32	56.84	11.56	56.78	11.81	58
59	57.92	11.26	57.87	11.51	57.82	11.76	57.76	12.01	59
60	58.90	11.45	58.85	11.71	58.80	11.96	58.74	12.22	60
61	59.88	11.64	59.83	11.90	59.78	12.16	59.72	12.42	61
62	60.86	11.83	60.81	12.10	60.76	12.36	60.70	12.63	62
63	61.84	12.02	61.79	12.29	61.74	12.56	61.68	12.83	63
64	62.82	12.21	62.77	12.49	62.72	12.76	62.66	13.03	64
65	63.81	12.40	63.75	12.68	63.70	12.96	63.64	13.24	65
66	64.79	12.59	64.73	12.88	64.68	13.16	64.62	13.44	66
67	65.77	12.78	65.71	13.07	65.66	13.36	65.60	13.64	67
68	66.75	12.98	66.69	13.27	66.63	13.56	66.58	13.85	68
69	67.73	13.17	67.67	13.46	67.61	13.76	67.55	14.05	69
70	68.71	13.36	68.66	13.66	68.59	13.96	68.53	14.25	70
71	69.70	13.55	69.64	13.85	69.57	14.16	69.51	14.46	71
72	70.68	13.74	70.62	14.05	70.55	14.35	70.49	14.66	72
73	71.66	13.93	71.60	14.24	71.53	14.55	71.47	14.87	73
74	72.64	14.12	72.58	14.44	72.51	14.75	72.45	15.07	74
75	73.62	14.31	73.56	14.63	73.49	14.95	73.43	15.27	75
76	74.60	14.50	74.54	14.83	74.47	15.15	74.41	15.48	76
77	75.59	14.69	75.52	15.02	75.45	15.35	75.39	15.68	77
78	76.57	14.88	76.50	15.22	76.43	15.55	76.37	15.88	78
79	77.55	15.07	77.48	15.41	77.41	15.75	77.34	16.09	79
80	78.53	15.26	78.46	15.61	78.39	15.95	78.32	16.29	80
81	79.51	15.46	79.44	15.80	79.37	16.15	79.30	16.49	81
82	80.49	15.65	80.42	16.00	80.35	16.35	80.28	16.70	82
83	81.48	15.84	81.41	16.19	81.33	16.55	81.26	16.90	83
84	82.46	16.03	82.39	16.39	82.31	16.75	82.24	17.11	84
85	83.44	16.22	83.37	16.58	83.29	16.95	83.22	17.31	85
86	84.42	16.41	84.35	16.78	84.27	17.15	84.20	17.51	86
87	85.40	16.60	85.33	16.97	85.25	17.35	85.18	17.72	87
88	86.38	16.79	86.31	17.17	86.23	17.54	86.16	17.92	88
89	87.36	16.98	87.29	17.36	87.21	17.74	87.14	18.12	89
90	88.35	17.17	88.27	17.56	88.19	17.94	88.11	18.33	90
91	89.33	17.36	89.25	17.75	89.17	18.14	89.09	18.53	91
92	90.31	17.55	90.23	17.95	90.15	18.34	90.07	18.74	92
93	91.29	17.75	91.21	18.14	91.13	18.54	91.05	18.94	93
94	92.27	17.94	92.19	18.34	92.11	18.74	92.03	19.14	94
95	93.25	18.13	93.17	18.53	93.09	18.94	93.01	19.35	95
96	94.24	18.32	94.16	18.73	94.07	19.14	93.99	19.55	96
97	95.22	18.51	95.14	18.92	95.05	19.34	94.97	19.75	97
98	96.20	18.70	96.12	19.12	96.03	19.54	95.95	19.96	98
99	97.18	18.89	97.10	19.31	97.01	19.74	96.93	20.16	99
100	98.16	19.08	98.08	19.51	97.99	19.94	97.90	20.36	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		

Distance.	12 Deg		12¼ Deg.		12½ Deg.		12¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.21	0.98	0.21	0.98	0.22	0.98	0.22	1
2	1.96	0.42	1.95	0.42	1.95	0.43	1.95	0.44	2
3	2.93	0.62	2.93	0.64	2.93	0.65	2.93	0.66	3
4	3.91	0.83	3.91	0.85	3.91	0.87	3.90	0.88	4
5	4.89	1.04	4.89	1.06	4.88	1.08	4.88	1.10	5
6	5.87	1.25	5.86	1.27	5.86	1.30	5.85	1.32	6
7	6.85	1.46	6.84	1.49	6.83	1.52	6.83	1.54	7
8	7.83	1.66	7.82	1.70	7.81	1.73	7.80	1.77	8
9	8.80	1.87	8.80	1.91	8.79	1.95	8.78	1.99	9
10	9.78	2.08	9.77	2.12	9.76	2.16	9.75	2.21	10
11	10.76	2.29	10.75	2.33	10.74	2.38	10.73	2.43	11
12	11.74	2.49	11.73	2.55	11.72	2.60	11.70	2.65	12
13	12.72	2.70	12.70	2.76	12.69	2.81	12.68	2.87	13
14	13.69	2.91	13.68	2.97	13.67	3.03	13.65	3.09	14
15	14.67	3.12	14.66	3.18	14.64	3.25	14.63	3.31	15
16	15.65	3.33	15.64	3.39	15.62	3.46	15.61	3.53	16
17	16.63	3.53	16.61	3.61	16.60	3.68	16.58	3.75	17
18	17.61	3.74	17.59	3.82	17.57	3.90	17.56	3.97	18
19	18.58	3.95	18.57	4.03	18.55	4.11	18.53	4.19	19
20	19.56	4.16	19.54	4.24	19.53	4.33	19.51	4.41	20
21	20.54	4.37	20.52	4.46	20.50	4.55	20.48	4.63	21
22	21.52	4.57	21.50	4.67	21.48	4.76	21.46	4.86	22
23	22.50	4.78	22.48	4.88	22.45	4.98	22.43	5.08	23
24	23.48	4.99	23.45	5.09	23.43	5.19	23.41	5.30	24
25	24.45	5.20	24.43	5.30	24.41	5.41	24.38	5.52	25
26	25.43	5.41	25.41	5.52	25.38	5.63	25.36	5.74	26
27	26.41	5.61	26.39	5.73	26.36	5.84	26.33	5.96	27
28	27.39	5.82	27.36	5.94	27.34	6.06	27.31	6.18	28
29	28.37	6.03	28.34	6.15	28.31	6.28	28.28	6.40	29
30	29.34	6.24	29.32	6.37	29.29	6.49	29.26	6.62	30
31	30.32	6.45	30.29	6.58	30.27	6.71	30.24	6.84	31
32	31.30	6.65	31.27	6.79	31.24	6.93	31.21	7.06	32
33	32.28	6.86	32.25	7.00	32.22	7.14	32.19	7.28	33
34	33.26	7.07	33.23	7.21	33.19	7.36	33.16	7.50	34
35	34.24	7.28	34.20	7.43	34.17	7.58	34.14	7.72	35
36	35.21	7.48	35.18	7.64	35.15	7.79	35.11	7.95	36
37	36.19	7.69	36.16	7.85	36.12	8.01	36.09	8.17	37
38	37.17	7.90	37.13	8.06	37.10	8.22	37.06	8.39	38
39	38.15	8.11	38.11	8.27	38.08	8.44	38.04	8.61	39
40	39.13	8.32	39.09	8.49	39.05	8.66	39.01	8.83	40
41	40.10	8.52	40.07	8.70	40.03	8.87	39.99	9.05	41
42	41.08	8.73	41.04	8.91	41.00	9.09	40.96	9.27	42
43	42.06	8.94	42.02	9.12	41.98	9.31	41.94	9.49	43
44	43.04	9.15	43.00	9.34	42.96	9.52	42.92	9.71	44
45	44.02	9.36	43.98	9.55	43.93	9.74	43.89	9.93	45
46	44.99	9.56	44.95	9.76	44.91	9.96	44.87	10.15	46
47	45.97	9.77	45.93	9.97	45.89	10.17	45.84	10.37	47
48	46.95	9.98	46.91	10.18	46.86	10.39	46.82	10.59	48
49	47.93	10.19	47.88	10.40	47.84	10.61	47.79	10.81	49
50	48.91	10.40	48.86	10.61	48.81	10.82	48.77	11.03	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	78 Deg		77¾ Deg.		77½ Deg.		77¼ Deg.		

Distance.	12 Deg.		12¼ Deg.		12½ Deg.		12¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.39	10.60	49.84	10.82	49.79	11.04	49.74	11.26	51
52	50.86	10.81	50.82	11.03	50.77	11.25	50.72	11.48	52
53	51.84	11.02	51.79	11.25	51.74	11.47	51.69	11.70	53
54	52.82	11.23	52.77	11.46	52.72	11.69	52.67	11.92	54
55	53.80	11.44	53.75	11.67	53.70	11.90	53.64	12.14	55
56	54.78	11.64	54.72	11.88	54.67	12.12	54.62	12.36	56
57	55.75	11.85	55.70	12.09	55.65	12.34	55.59	12.58	57
58	56.73	12.06	56.68	12.31	56.63	12.55	56.57	12.80	58
59	57.71	12.27	57.66	12.52	57.60	12.77	57.55	13.02	59
60	58.69	12.47	58.63	12.73	58.58	12.99	58.52	13.24	60
61	59.67	12.68	59.61	12.94	59.55	13.20	59.50	13.46	61
62	60.65	12.89	60.59	13.16	60.53	13.42	60.47	13.68	62
63	61.62	13.10	61.57	13.37	61.51	13.64	61.45	13.90	63
64	62.60	13.31	62.54	13.58	62.48	13.85	62.42	14.12	64
65	63.58	13.51	63.52	13.79	63.46	14.07	63.40	14.35	65
66	64.56	13.72	64.50	14.00	64.44	14.29	64.37	14.57	66
67	65.54	13.93	65.47	14.22	65.41	14.50	65.35	14.79	67
68	66.51	14.14	66.45	14.43	66.39	14.72	66.32	15.01	68
69	67.49	14.35	67.43	14.64	67.36	14.93	67.30	15.23	69
70	68.47	14.55	68.41	14.85	68.34	15.15	68.27	15.45	70
71	69.45	14.76	69.38	15.06	69.32	15.37	69.25	15.67	71
72	70.43	14.97	70.36	15.28	70.29	15.58	70.22	15.89	72
73	71.40	15.18	71.34	15.49	71.27	15.80	71.20	16.11	73
74	72.38	15.39	72.32	15.70	72.25	16.02	72.18	16.33	74
75	73.36	15.59	73.29	15.91	73.22	16.23	73.15	16.55	75
76	74.34	15.80	74.27	16.13	74.20	16.45	74.13	16.77	76
77	75.32	16.01	75.25	16.34	75.17	16.67	75.10	16.99	77
78	76.30	16.22	76.22	16.55	76.15	16.88	76.08	17.21	78
79	77.27	16.43	77.20	16.76	77.13	17.10	77.05	17.44	79
80	78.25	16.63	78.18	16.97	78.10	17.32	78.03	17.66	80
81	79.23	16.84	79.16	17.19	79.08	17.53	79.00	17.88	81
82	80.21	17.05	80.13	17.40	80.06	17.75	79.98	18.10	82
83	81.19	17.26	81.11	17.61	81.03	17.96	80.95	18.32	83
84	82.16	17.46	82.09	17.82	82.01	18.18	81.93	18.54	84
85	83.14	17.67	83.06	18.04	82.99	18.40	82.90	18.76	85
86	84.12	17.88	84.04	18.25	83.96	18.61	83.88	18.98	86
87	85.10	18.09	85.02	18.46	84.94	18.83	84.85	19.20	87
88	86.08	18.30	86.00	18.67	85.91	19.05	85.83	19.42	88
89	87.06	18.50	86.97	18.88	86.89	19.26	86.81	19.64	89
90	88.03	18.71	87.95	19.10	87.87	19.48	87.78	19.86	90
91	89.01	18.92	88.93	19.31	88.84	19.70	88.76	20.08	91
92	89.99	19.13	89.91	19.52	89.82	19.91	89.73	20.30	92
93	90.97	19.34	90.88	19.73	90.80	20.13	90.71	20.52	93
94	91.95	19.54	91.86	19.94	91.77	20.35	91.68	20.75	94
95	92.92	19.75	92.84	20.16	92.75	20.56	92.66	20.97	95
96	93.90	19.96	93.81	20.37	93.72	20.78	93.63	21.19	96
97	94.88	20.17	94.79	20.58	94.70	20.99	94.61	21.41	97
98	95.86	20.38	95.77	20.79	95.68	21.21	95.58	21.63	98
99	96.84	20.58	96.75	21.01	96.65	21.43	96.56	21.85	99
100	97.81	20.79	97.72	21.22	97.63	21.64	97.53	22.07	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	78 Deg.		77¾ Deg.		77½ Deg.		77¼ Deg.		

Distance.	13 Deg.		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.22	0.97	0.23	0.97	0.23	0.97	0.24	1
2	1.95	0.45	1.95	0.46	1.95	0.47	1.94	0.48	2
3	2 92	0.67	2.92	0.69	2.92	0.70	2.91	0.71	3
4	3.90	0.90	3.89	0.92	3.89	0.93	3.89	0.95	4
5	4.87	1.12	4.87	1.15	4.86	1.17	4.86	1.19	5
6	5.85	1.35	5.84	1.38	5.83	1.40	5.83	1.43	6
7	6.82	1.57	6.81	1.60	6.81	1.63	6.80	1.66	7
8	7.80	1.80	7.79	1.83	7.78	1.87	7.77	1.90	8
9	8.77	2.02	8.76	2.06	8.75	2.10	8.74	2.14	9
10	9.74	2.25	9.73	2.29	9.72	2.33	9.71	2.38	10
11	10.72	2.47	10.71	2.52	10.70	2.57	10.68	2.61	11
12	11.69	2.70	11.68	2.75	11.67	2.80	11.66	2.85	12
13	12.67	2.92	12.65	2.98	12.64	3.03	12.63	3.09	13
14	13.64	3.15	13.63	3.21	13.61	3.27	13.60	3.33	14
15	14.62	3.37	14.60	3.44	14.59	3.50	14.57	3.57	15
16	15.59	3.60	15.57	3.67	15.56	3.74	15.54	3.80	16
17	16.57	3.82	16.55	3.90	16.53	3.97	16.51	4.04	17
18	17.54	4.05	17.52	4.13	17.50	4.20	17.48	4.28	18
19	18.51	4.27	18.49	4.35	18.48	4.44	18.46	4.52	19
20	19.49	4.50	19.47	4.58	19.45	4.67	19.43	4.75	20
21	20.46	4.72	20.44	4.81	20.42	4.90	20.40	4.99	21
22	21.44	4.95	21.41	5.04	21.39	5.14	21.37	5.23	22
23	22.41	5.17	22.39	5.27	22.36	5.37	22.34	5.47	23
24	23.38	5.40	23.36	5.50	23.34	5.60	23.31	5.70	24
25	24.36	5.62	24.33	5.73	24.31	5.84	24.28	5.94	25
26	25.33	5.85	25.31	5.96	25.28	6.07	25.25	6.18	26
27	26.31	6.07	26.28	6.19	26.25	6.30	26.23	6.42	27
28	27.28	6.30	27.25	6.42	27.23	6.54	27.20	6.66	28
29	28.26	6.52	28.23	6.65	28.20	6.77	28.17	6.89	29
30	29.23	6.75	29.20	6.88	29.17	7.00	29.14	7.13	30
31	30.21	6.97	30.17	7.11	30.14	7.24	30.11	7.37	31
32	31.18	7.20	31.15	7.33	31.12	7.47	31.08	7.61	32
33	32.15	7.42	32.12	7.56	32.09	7.70	32.05	7.84	33
34	33.13	7.65	33.09	7.79	33.06	7.94	33.03	8.08	34
35	34.10	7.87	34.07	8.02	34.03	8.17	34.00	8.32	35
36	35.08	8.10	35.04	8.25	35.01	8.40	34.97	8.56	36
37	36.05	8.32	36.02	8.48	35.98	8.64	35.94	8.79	37
38	37.03	8.55	36.99	8.71	36.95	8.87	36.91	9.03	38
39	38.00	8.77	37.96	8.94	37.92	9.10	37.88	9.27	39
40	38.97	9.00	38.94	9.17	38.89	9.34	38.85	9.51	40
41	39.95	9.22	39.91	9.40	39.87	9.57	39.83	9.75	41
42	40.92	9.45	40.88	9.63	40.84	9.80	40.80	9.98	42
43	41.90	9 67	41.86	9.86	41.81	10.04	41.77	10.22	43
44	42.87	9.90	42.83	10.08	42.78	10.27	42.74	10.46	44
45	43.85	10.12	43.80	10.31	43.76	10.51	43.71	10.70	45
46	44.82	10.35	44.78	10.54	44.73	10.74	44.68	10.93	46
47	45.80	10.57	45.75	10.77	45.70	10.97	45.65	11.17	47
48	46 77	10.80	46.72	11.00	46.67	11.21	46.62	11.41	48
49	47.74	11.02	47.70	11.23	47.65	11.44	47.60	11.65	49
50	48.72	11.25	48.67	11.46	48.62	11.67	48.57	11.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	13 Deg		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.69	11.47	49.64	11.69	49.59	11.91	49.54	12.12	51
52	50.67	11.70	50.62	11.92	50.56	12.14	50.51	12.36	52
53	51.64	11.92	51.59	12.15	51.54	12.37	51.48	12.60	53
54	52.62	12.15	52.56	12.38	52.51	12.61	52.45	12.84	54
55	53.59	12.37	53.54	12.61	53.48	12.84	53.42	13.07	55
56	54.56	12.60	54.51	12.84	54.45	13.07	54.40	13.31	56
57	55 54	12.82	55.48	13.06	55.43	13.31	55.37	13.55	57
58	56.51	13.05	56.46	13.29	56.40	13.54	56.34	13.79	58
59	57.49	13.27	57.43	13.52	57.37	13.77	57.31	14.02	59
60	58.46	13.50	58.40	13.75	58.34	14.01	58.28	14.26	60
61	59.44	13.72	59.38	13.98	59.31	14.24	59.25	14.50	61
62	60.41	13.95	60.35	14.21	60.29	14.47	60.22	14.74	62
63	61.39	14.17	61.32	14.44	61.26	14.71	61.19	14.97	63
64	62.36	14.40	62.30	14.67	62.23	14.94	62.17	15.21	64
65	63.33	14.62	63.27	14.90	63.20	15.17	63.14	15.45	65
66	64.31	14.85	64.24	15.13	64.18	15.41	64.11	15.69	66
67	65.28	15.07	65.22	15.36	65.15	15.64	65.08	15.93	67
68	66.26	15.30	66.19	15.59	66.12	15.87	66.05	16.16	68
69	67.23	15.52	67.10	15.81	67.09	16.11	67.02	16.40	69
70	68.21	15.75	68.14	16.04	68.07	16.34	67.99	16.64	70
71	69.18	15.97	69.11	16.27	69.04	16.57	68.97	16.88	71
72	70.15	16.20	70.08	16.50	70.01	16.81	69.94	17.11	72
73	71.13	16.42	71.06	16.73	70.98	17.04	70.91	17.35	73
74	72.10	16.65	72.03	16.96	71.96	17.28	71.88	17.59	74
75	73.08	16.87	73.00	17.19	72.93	17.50	72.85	17.83	75
76	74.05	17.10	73.98	17.42	73.90	17.74	73.82	18.06	76
77	75.03	17.32	74.95	17.65	74.87	17.98	74.79	18.30	77
78	76.00	17.55	75.92	17.88	75.84	18.21	75.76	18.54	78
79	76.98	17.77	76.90	18.11	76.82	18.44	76.74	18.78	79
80	77.95	18.00	77.87	18.34	77.79	18.68	77.71	19.01	80
81	78.92	18.22	78.84	18.57	78.76	18.91	78.68	19.25	81
82	79.90	18.45	79.82	18.79	79.73	19.14	79.65	19.49	82
83	80.87	18.67	80.79	19.02	80.71	19.38	80.62	19.73	83
84	81.85	18.90	81.76	19.25	81.68	19.61	81.59	19.97	84
85	82.82	19.12	82.74	19.48	82.65	19.84	82.56	20.20	85
86	83.80	19.35	83.71	19.71	83.62	20.08	83.54	20.44	86
87	84.77	19.57	84.68	19.94	84.60	20.31	84.51	20.68	87
88	85.74	19.80	85.66	20.17	85.57	20.54	85.48	20.92	88
89	86.72	20.02	86.63	20.40	86.54	20.78	86.45	21.15	89
90	87.69	20.25	87.60	20.63	87.51	21.01	87.42	21.39	90
91	88.67	20.47	88.58	20.86	88.49	21.24	88.39	21.63	91
92	89.64	20.70	89.55	21.09	89.46	21.48	89.36	21.87	92
93	90.62	20.92	90.52	21.32	90.43	21.71	90.33	22.10	93
94	91.59	21.15	91.50	21.54	91.40	21.94	91.31	22.34	94
95	92.57	21.37	92.47	21.77	92.38	22.18	92.28	22.58	95
96	93.54	21.60	93.44	22.00	93.35	22.41	93.25	22.82	96
97	94 51	21.82	94.42	22.23	94.32	22.64	94.22	23.06	97
98	95 49	22.05	95.39	22.46	95.29	22.88	95.19	23.29	98
99	96 46	22.27	96.36	22.69	96.26	23.11	96.16	23.53	99
100	97.44	22.50	97.34	22.92	97.24	23.34	97.13	23 77	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	14 Deg.		14¼ Deg.		14½ Deg.		14¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.24	0.97	0.25	0.97	0.25	0.97	0.25	1
2	1.94	0.48	1.94	0.49	1.94	0.50	1.93	0.51	2
3	2.91	0.73	2.91	0.74	2.90	0.75	2.90	0.76	3
4	3.88	0.97	3.88	0.98	3.87	1.00	3.87	1.02	4
5	4.85	1.21	4.85	1.23	4.84	1.25	4.84	1.27	5
6	5.82	1.45	5.82	1.48	5.81	1.50	5.80	1.53	6
7	6.79	1.69	6.78	1.72	6.78	1.75	6.77	1.78	7
8	7.76	1.94	7.75	1.97	7.75	2.00	7.74	2.04	8
9	8.73	2.18	8.72	2.22	8.71	2.25	8.70	2.29	9
10	9.70	2.42	9.69	2.46	9.68	2.50	9.67	2.55	10
11	10.67	2.66	10.66	2.71	10.65	2.75	10.64	2.80	11
12	11.64	2.90	11.63	2.95	11.62	3.00	11.60	3.06	12
13	12.61	3.15	12.60	3.20	12.59	3.25	12.57	3.31	13
14	13.58	3.39	13.57	3.45	13.55	3.51	13.54	3.56	14
15	14.55	3.63	14.54	3.69	14.52	3.76	14.51	3.82	15
16	15.52	3.87	15.51	3.94	15.49	4.01	15.47	4.07	16
17	16.50	4.11	16.48	4.18	16.46	4.26	16.44	4.33	17
18	17.47	4.35	17.45	4.43	17.43	4.51	17.41	4.58	18
19	18.44	4.60	18.42	4.68	18.39	4.76	18.37	4.84	19
20	19.41	4.84	19.38	4.92	19.36	5.01	19.34	5.09	20
21	20.38	5.08	20.35	5.17	20.33	5.26	20.31	5.35	21
22	21.35	5.32	21.32	5.42	21.30	5.51	21.28	5.60	22
23	22.32	5.56	22.29	5.66	22.27	5.76	22.24	5.86	23
24	23.29	5.81	23.26	5.91	23.24	6.01	23.21	6.11	24
25	24.26	6.05	24.23	6.15	24.20	6.26	24.18	6.37	25
26	25.23	6.29	25.20	6.40	25.17	6.51	25.14	6.62	26
27	26.20	6.53	26.17	6.65	26.14	6.76	26.11	6.87	27
28	27.17	6.77	27.14	6.89	27.11	7.01	27.08	7.13	28
29	28.14	7.02	28.11	7.14	28.08	7.26	28.04	7.38	29
30	29.11	7.26	29.08	7.38	29.04	7.51	29.01	7.64	30
31	30.08	7.50	30.05	7.63	30.01	7.76	29.98	7.89	31
32	31.05	7.74	31.02	7.88	30.98	8.01	30.95	8.15	32
33	32.02	7.98	31.98	8.12	31.95	8.26	31.91	8.40	33
34	32.99	8.23	32.95	8.37	32.92	8.51	32.88	8.66	34
35	33.96	8.47	33.92	8.62	33.89	8.76	33.85	8.91	35
36	34.93	8.71	34.89	8.86	34.85	9.01	34.81	9.17	36
37	35.90	8.95	35.86	9.11	35.82	9.26	35.78	9.42	37
38	36.87	9.19	36.83	9.35	36.79	9.51	36.75	9.67	38
39	37.84	9.44	37.80	9.60	37.76	9.76	37.71	9.93	39
40	38.81	9.68	38.77	9.85	38.73	10.02	38.68	10.18	40
41	39.78	9.92	39.74	10.09	39.69	10.27	39.65	10.44	41
42	40.75	10.16	40.71	10.34	40.66	10.52	40.62	10.69	42
43	41.72	10.40	41.68	10.58	41.63	10.77	41.58	10.95	43
44	42.69	10.64	42.65	10.83	42.60	11.02	42.55	11.20	44
45	43.66	10.89	43.62	11.08	43.57	11.27	43.52	11.46	45
46	44.63	11.13	44.58	11.32	44.53	11.52	44.48	11.71	46
47	45.60	11.37	45.55	11.57	45.50	11.77	45.45	11.97	47
48	46.57	11.61	46.52	11.82	46.47	12.02	46.42	12.22	48
49	47.54	11.85	47.49	12.06	47.44	12.27	47.39	12.48	49
50	48.51	12.10	48.46	12.31	48.41	12.52	48.35	12.73	50
Distance.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	76 Deg.		75¾ Deg.		75½ Deg.		75¼ Deg.		

Distance.	14 Deg.		14¼ Deg.		14½ Deg.		14¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.49	12.34	49.43	12.55	49.38	12.77	49.32	12.98	51
52	50.46	12.58	50.40	12.80	50.34	13.02	50.29	13.24	52
53	51.43	12.82	51.37	13.05	51.31	13.27	51.25	13.49	53
54	52.40	13.06	52.34	13.29	52.28	13.52	52.22	13.75	54
55	53.37	13.31	53.31	13.54	53.25	13.77	53.19	14.00	55
56	54.34	13.55	54.28	13.78	54.22	14.02	54.15	14.26	56
57	55.31	13.79	55.25	14.03	55.18	14.27	55.12	14.51	57
58	56.28	14.03	56.22	14.28	56.15	14.52	56.09	14.77	58
59	57.25	14.27	57.18	14.52	57.12	14.77	57.06	15.02	59
60	58.22	14.52	58.15	14.77	58.09	15.02	58.02	15.28	60
61	59.19	14.76	59.12	15.02	59.06	15.27	58.99	15.53	61
62	60.16	15.00	60.09	15.26	60.03	15.52	59.96	15.79	62
63	61.13	15.24	61.06	15.51	60.99	15.77	60.92	16.04	63
64	62.10	15.48	62.03	15.75	61.96	16.02	61.89	16.29	64
65	63.07	15.72	63.00	16.00	62.93	16.27	62.86	16.55	65
66	64.04	15.97	63.97	16.25	63.90	16.53	63.83	16.80	66
67	65.01	16.21	64.94	16.49	64.87	16.78	64.79	17.06	67
68	65.98	16.45	65.91	16.74	65.83	17.03	65.76	17.31	68
69	66.95	16.69	66.88	16.98	66.80	17.28	66.73	17.57	69
70	67.92	16.93	67.85	17.23	67.77	17.53	67.69	17.82	70
71	68.89	17.18	68.82	17.48	68.74	17.78	68.66	18.08	71
72	69.86	17.42	69.78	17.72	69.71	18.03	69.63	18.33	72
73	70.83	17.66	70.75	17.97	70.67	18.28	70.59	18.59	73
74	71.80	17.90	71.72	18.22	71.64	18.53	71.56	18.84	74
75	72.77	18.14	72.69	18.46	72.61	18.78	72.53	19.10	75
76	73.74	18.39	73.66	18.71	73.58	19.03	73.50	19.35	76
77	74.71	18.63	74.63	18.95	74.55	19.28	74.46	19.60	77
78	75.68	18.87	75.60	19.20	75.52	19.53	75.43	19.86	78
79	76.65	19.11	76.57	19.45	76.48	19.78	76.40	20.11	79
80	77.62	19.35	77.54	19.69	77.45	20.03	77.36	20.37	80
81	78.59	19.60	78.51	19.94	78.42	20.28	78.33	20.62	81
82	79.56	19.84	79.48	20.18	79.39	20.53	79.30	20.88	82
83	80.53	20.08	80.45	20.43	80.36	20.78	80.26	21.13	83
84	81.50	20.32	81.42	20.68	81.32	21.03	81.23	21.39	84
85	82.48	20.56	82.38	20.92	82.29	21.28	82.20	21.64	85
86	83.45	20.81	83.35	21.17	83.26	21.53	83.17	21.90	86
87	84.42	21.05	84.32	21.42	84.23	21.78	84.13	22.15	87
88	85.39	21.29	85.29	21.66	85.20	22.03	85.10	22.41	88
89	86.36	21.53	86.26	21.91	86.17	22.28	86.07	22.66	89
90	87.33	21.77	87.23	22.15	87.13	22.53	87.03	22.91	90
91	88.30	22.01	88.20	22.40	88.10	22.78	88.00	23.17	91
92	89.27	22.26	89.17	22.65	89.07	23.04	88.97	23.42	92
93	90.24	22.50	90.14	22.89	90.04	23.29	89.94	23.68	93
94	91.21	22.74	91.11	23.14	91.01	23.54	90.90	23.93	94
95	92.18	22.98	92.08	23.38	91.97	23.79	91.87	24.19	95
96	93.15	23.22	93.05	23.63	92.94	24.04	92.84	24.44	96
97	94.12	23.47	94.02	23.88	93.91	24.29	93.80	24.70	97
98	95.09	23.71	94.98	24.12	94.88	24.54	94.77	24.95	98
99	96.06	23.95	95.95	24.37	95.85	24.79	95.74	25.21	99
100	97.03	24.19	96.92	24.62	96.81	25.04	96.70	25.46	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	76 Deg.		75¾ Deg		75½ Deg.		75¼ Deg		

Distance.	15 Deg.		15¼ Deg.		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.26	0.96	0.26	0.96	0.27	0.96	0.27	1
2	1.93	0.52	1.93	0.53	1.93	0.53	1.92	0.54	2
3	2.90	0.78	2.89	0.79	2.89	0.80	2.89	0.81	3
4	3.86	1.04	3.86	1.05	3.85	1.07	3.85	1.09	4
5	4.83	1.29	4.82	1.32	4.82	1.34	4.81	1.36	5
6	5.80	1.55	5.79	1.58	5.78	1.60	5.77	1.63	6
7	6.76	1.81	6.75	1.84	6.75	1.87	6.74	1.90	7
8	7.73	2.07	7.72	2.10	7.71	2.14	7.70	2.17	8
9	8.69	2.33	8.68	2.37	8.67	2.41	8.66	2.44	9
10	9.66	2.59	9.65	2.63	9.64	2.67	9.62	2.71	10
11	10.63	2.85	10.61	2.89	10.60	2.94	10.59	2.99	11
12	11.59	3.11	11.58	3.16	11.56	3.21	11.55	3.26	12
13	12.56	3.36	12.54	3.42	12.53	3.47	12.51	3.53	13
14	13.52	3.62	13.51	3.68	13.49	3.74	13.47	3.80	14
15	14.49	3.88	14.47	3.95	14.45	4.01	14.44	4.07	15
16	15.45	4.14	15.44	4.21	15.42	4.28	15.40	4.34	16
17	16.42	4.40	16.40	4.47	16.38	4.54	16.36	4.61	17
18	17.39	4.66	17.37	4.73	17.35	4.81	17.32	4.89	18
19	18.35	4.92	18.33	5.00	18.31	5.08	18.29	5.16	19
20	19.32	5.18	19.30	5.26	19.27	5.34	19.25	5.43	20
21	20.28	5.44	20.26	5.52	20.24	5.61	20.21	5.70	21
22	21.25	5.69	21.23	5.79	21.20	5.88	21.17	5.97	22
23	22.22	5.95	22.19	6.05	22.16	6.15	22.14	6.24	23
24	23.18	6.21	23.15	6.31	23.13	6.41	23.10	6.51	24
25	24.15	6.47	24.12	6.58	24.09	6.68	24.06	6.79	25
26	25.11	6.73	25.08	6.84	25.05	6.95	25.02	7.06	26
27	26.08	6.99	26.05	7.10	26.02	7.22	25.99	7.33	27
28	27.05	7.25	27.01	7.36	26.98	7.48	26.95	7.60	28
29	28.01	7.51	27.98	7.63	27.95	7.75	27.91	7.87	29
30	28.98	7.76	28.94	7.89	28.91	8.02	28.87	8.14	30
31	29.94	8.02	29.91	8.15	29.87	8.28	29.84	8.41	31
32	30.91	8.28	30.87	8.42	30.84	8.55	30.80	8.69	32
33	31.88	8.54	31.84	8.68	31.80	8.82	31.76	8.96	33
34	32.84	8.80	32.80	8.94	32.76	9.09	32.72	9.23	34
35	33.81	9.06	33.77	9.21	33.73	9.35	33.69	9.50	35
36	34.77	9.32	34.73	9.47	34.69	9.62	34.65	9.77	36
37	35.74	9.58	35.70	9.73	35.65	9.89	35.61	10.04	37
38	36.71	9.84	36.66	10.00	36.62	10.16	36.57	10.31	38
39	37.67	10.09	37.63	10.26	37.58	10.42	37.54	10.59	39
40	38.64	10.35	38.59	10.52	38.55	10.69	38.50	10.86	40
41	39.60	10.61	39.56	10.78	39.51	10.96	39.46	11.13	41
42	40.57	10.87	40.52	11.05	40.47	11.22	40.42	11.40	42
43	41.53	11.13	41.49	11.31	41.44	11.49	41.39	11.67	43
44	42.50	11.39	42.45	11.57	42.40	11.76	42.35	11.94	44
45	43.47	11.65	43.42	11.84	43.36	12.03	43.31	12.21	45
46	44.43	11.91	44.38	12.10	44.33	12.29	44.27	12.49	46
47	45.40	12.16	45 35	12.36	45.29	12.56	45.24	12.76	47
48	46.36	12.42	46.31	12.63	46.25	12.83	46.20	13.03	48
49	47.33	12.68	47.27	12.89	47.22	13.09	47.16	13.30	49
50	48.30	12.94	48.24	13.15	48.18	13.36	48.12	13.57	50
Distance.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance.	15 Deg.		15¼ Deg		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.26	13.20	49.20	13.41	49.15	13.63	49.09	13.84	51
52	50.23	13.46	50.17	13.68	50.11	13.90	50.05	14.11	52
53	51.19	13.72	51.13	13.94	51.07	14.16	51.01	14.39	53
54	52.16	13.98	52.10	14.20	52.04	14.43	51.97	14.66	54
55	53.13	14.24	53.06	14.47	53.00	14.70	52.94	14.93	55
56	54.09	14.49	54.03	14.73	53.96	14.97	53.90	15.20	56
57	55.06	14.75	54.99	14.99	54.93	15.23	54.86	15.47	57
58	56.02	15.01	55.96	15.26	55.89	15.50	55.82	15.74	58
59	56.99	15.27	56.92	15.52	56.85	15.77	56.78	16.01	59
60	57.96	15.53	57.89	15.78	57.82	16.03	57.75	16.29	60
61	58.92	15.79	58.85	16.04	58.78	16.30	58.71	16.56	61
62	59.89	16.05	59.82	16.31	59.75	16.57	59.67	16.83	62
63	60.85	16.31	60.78	16.57	60.71	16.84	60.63	17.10	63
64	61.82	16.56	61.75	16.83	61.67	17.10	61.60	17.37	64
65	62.79	16.82	62.71	17.10	62.64	17.37	62.56	17.64	65
66	63.75	17.08	63.68	17.36	63.60	17.64	63.52	17.92	66
67	64.72	17.34	64.64	17.62	64.56	17.90	64.48	18.19	67
68	65.68	17.60	65.61	17.89	65.53	18.17	65.45	18.46	68
69	66.65	17.86	66.57	18.15	66.49	18.44	66.41	18.73	69
70	67.61	18.12	67.54	18.41	67.45	18.71	67.37	19.00	70
71	68.58	18.38	68.50	18.68	68.42	18.97	68.33	19.27	71
72	69.55	18.63	69.46	18.94	69.38	19.24	69.30	19.54	72
73	70.51	18.89	70.43	19.20	70.35	19.51	70.26	19.82	73
74	71.48	19.15	71.39	19.46	71.31	19.78	71.22	20.09	74
75	72.44	19.41	72.36	19.73	72.27	20.04	72.18	20.36	75
76	73.41	19.67	73.32	19.99	73.24	20.31	73.15	20.63	76
77	74.38	19.93	74.29	20.25	74.20	20.58	74.11	20.90	77
78	75.34	20.19	75.25	20.52	75.16	20.84	75.07	21.17	78
79	76.31	20.45	76.22	20.78	76.13	21.11	76.03	21.44	79
80	77.27	20.71	77.18	21.04	77.09	21.38	77.00	21.72	80
81	78.24	20.96	78.15	21.31	78.05	21.65	77.96	21.99	81
82	79.21	21.22	79.11	21.57	79.02	21.91	78.92	22.26	82
83	80.17	21.48	80.08	21.83	79.98	22.18	79.88	22.53	83
84	81.14	21.74	81.04	22.09	80.94	22.45	80.85	22.80	84
85	82.10	22.00	82.01	22.36	81.91	22.72	81.81	23.07	85
86	83.07	22.26	82.97	22.62	82.87	22.98	82.77	23.34	86
87	84.04	22.52	83.94	22.88	83.84	23.25	83.73	23.62	87
88	85.00	22.78	84.90	23.15	84.80	23.52	84.70	23.89	88
89	85.97	23.03	85.87	23.41	85.76	23.78	85.66	24.16	89
90	86.93	23.29	86.83	23.67	86.73	24.05	86.62	24.43	90
91	87.90	23.55	87.80	23.94	87.69	24.32	87.58	24.70	91
92	88.87	23.81	88.76	24.20	88.65	24.59	88.55	24.97	92
93	89.83	24.07	89.73	24.46	89.62	24.85	89.51	25.24	93
94	90.80	24.33	90.69	24.72	90.58	25.12	90.47	25.52	94
95	91.76	24.59	91.65	24.99	91.54	25.39	91.43	25.79	95
96	92.73	24.85	92.62	25.25	92.51	25.65	92.40	26.06	96
97	93.69	25.11	93.58	25.51	93.47	25.92	93.36	26.33	97
98	94.66	25.36	94.55	25.78	94.44	26.19	94.32	26.60	98
99	95.63	25.62	95.51	26.04	95.40	26.46	95.28	26.87	99
100	96.59	25.88	96.48	26.30	96.36	26.72	96.25	27.14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.28	0.96	0.28	0.96	0.28	0.96	0.29	1
2	1.92	0.55	1.92	0.56	1.92	0.57	1.92	0.58	2
3	2.88	0.83	2.88	0.84	2.88	0.85	2.87	0.86	3
4	3.85	1.10	3.84	1.12	3.84	1.14	3.83	1.15	4
5	4.81	1.38	4.80	1.40	4.79	1.42	4.79	1.44	5
6	5.77	1.65	5.76	1.68	5.75	1.70	5.75	1.73	6
7	6.73	1.93	6.72	1.96	6.71	1.99	6.70	2.02	7
8	7.69	2.21	7.68	2.24	7.67	2.27	7.66	2.31	8
9	8.65	2.48	8.64	2.52	8.63	2.56	8.62	2.59	9
10	9.61	2.76	9.60	2.80	9.59	2.84	9.58	2.88	10
11	10.57	3.03	10.56	3.08	10.55	3.12	10.53	3.17	11
12	11.54	3.31	11.52	3.36	11.51	3.41	11.49	3.46	12
13	12.50	3.58	12.48	3.64	12.46	3.69	12.45	3.75	13
14	13.46	3.86	13.44	3.92	13.42	3.98	13.41	4.03	14
15	14.42	4.13	14.40	4.20	14.38	4.26	14.36	4.32	15
16	15.38	4.41	15.36	4.48	15.34	4.54	15.32	4.61	16
17	16.34	4.69	16.32	4.76	16.30	4.83	16.28	4.90	17
18	17.30	4.96	17.28	5.04	17.26	5.11	17.24	5.19	18
19	18.26	5.24	18.24	5.32	18.22	5.40	18.19	5.48	19
20	19.23	5.51	19.20	5.60	19.18	5.68	19.15	5.76	20
21	20.19	5.79	20.16	5.88	20.14	5.96	20.11	6.05	21
22	21.15	6.06	21.12	6.16	21.09	6.25	21.07	6.34	22
23	22.11	6.34	22.08	6.44	22.05	6.53	22.02	6.63	23
24	23.07	6.62	23.04	6.72	23.01	6.82	22.98	6.92	24
25	24.03	6.89	24.00	7.00	23.97	7.10	23.94	7.20	25
26	24.99	7.17	24.96	7.28	24.93	7.38	24.90	7.49	26
27	25.95	7.44	25.92	7.56	25.89	7.67	25.85	7.78	27
28	26.92	7.72	26.88	7.84	26.85	7.95	26.81	8.07	28
29	27.88	7.99	27.84	8.11	27.81	8.24	27.77	8.36	29
30	28.84	8.27	28.80	8.39	28.76	8.52	28.73	8.65	30
31	29.80	8.54	29.76	8.67	29.72	8.80	29.68	8.93	31
32	30.76	8.82	30.72	8.95	30.68	9.09	30.64	9.22	32
33	31.72	9.10	31.68	9.23	31.64	9.37	31.60	9.51	33
34	32.68	9.37	32.64	9.51	32.60	9.66	32.56	9.80	34
35	33.64	9.65	33.60	9.79	33.56	9.94	33.51	10.09	35
36	34.61	9.92	34.56	10.07	34.52	10.22	34.47	10.38	36
37	35.57	10.20	35.52	10.35	35.48	10.51	35.43	10.66	37
38	36.53	10.47	36.48	10.63	36.41	10.79	36.39	10.95	38
39	37.49	10.75	37.44	10.91	37.39	11.08	37.35	11.24	39
40	38.45	11.03	38.40	11.19	38.35	11.36	38.30	11.53	40
41	39.41	11.30	39.36	11.47	39.31	11.64	39.26	11.82	41
42	40.37	11.58	40.32	11.75	40.27	11.93	40.22	12.10	42
43	41.33	11.85	41.28	12.03	41.23	12.21	41.18	12.39	43
44	42.30	12.13	42.24	12.31	42.19	12.50	42.13	12.68	44
45	43.26	12.40	43.20	12.59	43.15	12.78	43.09	12.97	45
46	44.22	12.68	44.16	12.87	44.11	13.06	44.05	13.26	46
47	45.18	12.95	45.12	13.15	45.06	13.35	45.01	13.55	47
48	46.14	13.23	46.08	13.43	46.02	13.63	45.96	13.83	48
49	47.10	13.51	47.04	13.71	46.98	13.92	46.92	14.12	49
50	48.06	13.78	48.00	13.99	47.94	14.20	47.88	14.41	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.02	14.06	48.96	14.27	48.90	14.48	48.84	14.70	51
52	49.99	14.33	49.92	14.55	49.86	14.77	49.79	14.99	52
53	50.95	14.61	50.88	14.83	50.82	15.05	50.75	15.27	53
54	51.91	14.88	51.84	15.11	51.78	15.34	51.71	15.56	54
55	52.87	15.16	52.80	15.39	52.74	15.62	52.67	15.85	55
56	53.83	15.44	53.76	15.67	53.69	15.90	53.62	16.14	56
57	54.79	15.71	54.72	15.95	54.65	16.19	54.58	16.43	57
58	55.75	15.99	55.68	16.23	55.61	16.47	55.54	16.72	58
59	56.71	16.26	56.64	16.51	56.57	16.76	56.50	17.00	59
60	57.68	16.54	57.60	16.79	57.53	17.04	57.45	17.29	60
61	58.64	16.81	58.56	17.07	58.49	17.32	58.41	17.58	61
62	59.60	17.09	59.52	17.35	59.45	17.61	59.37	17.87	62
63	60.56	17.37	50.48	17.63	60.41	17.89	60.33	18.16	63
64	61.52	17.64	61.44	17.91	61.36	18.18	61.28	18.44	64
65	62.48	17.92	62.40	18.19	62.32	18.46	62.24	18.73	65
66	63.44	18.19	63.36	18.47	63.28	18.74	63.20	19.02	66
67	64.40	18.47	64.32	18.75	64.24	19.03	64.16	19.31	67
68	65.37	18.74	65.28	19.03	65.20	19.31	65.11	19.60	68
69	66.33	19.02	66.24	19.31	66.16	19.60	66.07	19.89	69
70	67.29	19.29	67.20	19.59	67.12	19.88	67.03	20.17	70
71	68.25	19.57	68.16	19.87	68.08	20.17	67.99	20.46	71
72	69.21	19.85	69.12	20.15	69.03	20.45	68.95	20.75	72
73	70.17	20.12	70.08	20.43	69.99	20.73	69.90	21.04	73
74	71.13	20.40	71.04	20.71	70.95	21.02	70.86	21.33	74
75	72.09	20.67	72.00	20.99	71.91	21.30	71.82	21.61	75
76	73.06	20.95	72.96	21.27	72.87	21.59	72.78	21.90	76
77	74.02	21.22	73.92	21.55	73.83	21.87	73.73	22.19	77
78	74.98	21.50	74.88	21.83	74.79	22.15	74.69	22.48	78
79	75.94	21.78	75.84	22.11	75.75	22.44	75.65	22.77	79
80	76.90	22.05	76.80	22.39	76.71	22.72	76.61	23.06	80
81	77.86	22.33	77.76	22.67	77.66	23.01	77.56	23.34	81
82	78.82	22.60	78.72	22.95	78.62	23.29	78.52	23.63	82
83	79.78	22.88	79.68	23.23	79.58	23.57	79.48	23.92	83
84	80.75	23.15	80.64	23.51	80.54	23.86	80.44	24.21	84
85	81.71	23.43	81.60	23.79	81.50	24.14	81.39	24.50	85
86	82.67	23.70	82.56	24.07	82.46	24.43	82.35	24.78	86
87	83.63	23.98	83.52	24.35	83.42	24.71	83.31	25.07	87
88	84.59	24.26	84.48	24.62	84.38	24.99	84.27	25.36	88
89	85.55	24.53	85.44	24.90	85.33	25.28	85.22	25.65	89
90	86.51	24.81	86.40	25.18	86.29	25.56	86.18	25.94	90
91	87.47	25.08	87.36	25.46	87.25	25.85	87.14	26.23	91
92	88.44	25.36	88.32	25.74	88.21	26.13	88.10	26.51	92
93	89.40	25.63	89.28	26.02	89.17	26.41	89.05	26.80	93
94	90.36	25.91	90.24	26.30	90.13	26.70	90.01	27.09	94
95	91.32	26.19	91.20	26.58	91.09	26.98	90.97	27.38	95
96	92.28	26.46	92.16	26.86	92.05	27.27	91.93	27.67	96
97	93.24	26.74	93.12	27.14	93.01	27.55	92.88	27.95	97
98	94.20	27.01	94.08	27.42	93.96	27.83	93.84	28.24	98
99	95.16	27.29	95.04	27.70	94.92	28.12	94.80	28.53	99
100	96.13	27.56	96.00	27.98	95.88	28.40	95.76	28.82	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.29	0.95	0.30	0.95	0.30	0.95	0.30	1
2	1.91	0.58	1.91	0.59	1.91	0.60	1.90	0.61	2
3	2.87	0.88	2.87	0.89	2.86	0.90	2.86	0.91	3
4	3.83	1.17	3.82	1.19	3.81	1.20	3.81	1.22	4
5	4.78	1.46	4.78	1.48	4.77	1.50	4.76	1.52	5
6	5.74	1.75	5.73	1.78	5.72	1.80	5.71	1.83	6
7	6.69	2.05	6.69	2.08	6.68	2.10	6.67	2.13	7
8	7.65	2.34	7.64	2.37	7.63	2.41	7.62	2.44	8
9	8.61	2.63	8.60	2.67	8.58	2.71	8.57	2.74	9
10	9.56	2.92	9.55	2.97	9.54	3.01	9.52	3.05	10
11	10.52	3.22	10.51	3.26	10.49	3.31	10.48	3.35	11
12	11.48	3.51	11.46	3.56	11.44	3.61	11.43	3.66	12
13	12.43	3.80	12.42	3.85	12.40	3.91	12.38	3.96	13
14	13.39	4.09	13.37	4.15	13.35	4.21	13.33	4.27	14
15	14.34	4.39	14.33	4.45	14.31	4.51	14.29	4.57	15
16	15.30	4.68	15.28	4.74	15.26	4.81	15.24	4.88	16
17	16.26	4.97	16.24	5.04	16.21	5.11	16.19	5.18	17
18	17.21	5.26	17.19	5.34	17.17	5.41	17.14	5.49	18
19	18.17	5.56	18.15	5.63	18.12	5.71	18.10	5.79	19
20	19.13	5.85	19.10	5.93	19.07	6.01	19.05	6.10	20
21	20.08	6.14	20.06	6.23	20.03	6.31	20.00	6.40	21
22	21.04	6.43	21.01	6.52	20.98	6.62	20.95	6.71	22
23	21.99	6.72	21.97	6.82	21.94	6.92	21.91	7.01	23
24	22.95	7.02	22.92	7.12	22.89	7.22	22.86	7.32	24
25	23.91	7.31	23.88	7.41	23.84	7.52	23.81	7.62	25
26	24.86	7.60	24.83	7.71	24.80	7.82	24.76	7.93	26
27	25.82	7.89	25.79	8.01	25.75	8.12	25.71	8.23	27
28	26.78	8.19	26.74	8.30	26.70	8.42	26.67	8.54	28
29	27.73	8.48	27.70	8.60	27.66	8.72	27.62	8.84	29
30	28.69	8.77	28.65	8.90	28.61	9.02	28.57	9.15	30
31	29.65	9.06	29.61	9.19	29.57	9.32	29.52	9.45	31
32	30.60	9.36	30.56	9.49	30.52	9.62	30.48	9.76	32
33	31.56	9.65	31.52	9.79	31.47	9.92	31.43	10.06	33
34	32.51	9.94	32.47	10.08	32.43	10.22	32.38	10.37	34
35	33.47	10.23	33.43	10.38	33.38	10.52	33.33	10.67	35
36	34.43	10.53	34.38	10.68	34.33	10.83	34.29	10.98	36
37	35.38	10.82	35.34	10.97	35.29	11.13	35.24	11.28	37
38	36.34	11.11	36.29	11.27	36.24	11.43	36.19	11.58	38
39	37.30	11.40	37.25	11.57	37.19	11.73	37.14	11.89	39
40	38.25	11.69	38.20	11.86	38.15	12.03	38.10	12.19	40
41	39.21	11.99	39.16	12.16	39.10	12.33	39.05	12.50	41
42	40.16	12.28	40.11	12.45	40.06	12.63	40.00	12.80	42
43	41.12	12.57	41.07	12.75	41.01	12.93	40.95	13.11	43
44	42.08	12.86	42.02	13.05	41.96	13.23	41.91	13.41	44
45	43.03	13.16	42.98	13.34	42.92	13.53	42.86	13.72	45
46	43.99	13.45	43.93	13.64	43.87	13.83	43.81	14.02	46
47	44.95	13.74	44.89	13.94	44.82	14.13	44.76	14.33	47
48	45.90	14.03	45.84	14.23	45.78	14.43	45.71	14.63	48
49	46.86	14.33	46.80	14.53	46.73	14.73	46.67	14.94	49
50	47.82	14.62	47.75	14.83	47.69	15.04	47.62	15.24	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.77	14.91	48.71	15.12	48.64	15.34	48.57	15.55	51
52	49.73	15.20	49.66	15.42	49.59	15.64	49.52	15.85	52
53	50.68	15.50	50.62	15.72	50.55	15.94	50.48	16.16	53
54	51.64	15.79	51.57	16.01	51.50	16.24	51.43	16.46	54
55	52.60	16.08	52.53	16.31	52.45	16.54	52.38	16.77	55
56	53.55	16.37	53.48	16.61	53.41	16.84	53.33	17.07	56
57	54.51	16.67	54.44	16.90	54.36	17.14	54.29	17.38	57
58	55.47	16.96	55.39	17.20	55.32	17.44	55.24	17.68	58
59	56.42	17.25	56.35	17.50	56.27	17.74	56.10	17.99	59
60	57.38	17.54	57.30	17.79	57.22	18.04	57.14	18.29	60
61	58.33	17.83	58.26	18.09	58.18	18.34	58.10	18.60	61
62	59.29	18.13	59.21	18.39	59.13	18.64	59.05	18.90	62
63	60.25	18.42	60.17	18.68	60.08	18.94	60.00	19.21	63
64	61.20	18.71	61.12	18.98	61.04	19.25	60.95	19.51	64
65	62.16	19.00	62.08	19.28	61.99	19.55	61.91	19.82	65
66	63.12	19.30	63.03	19.57	62.95	19.35	62.86	20.12	66
67	64.07	19.59	63.99	19.87	63.90	20.15	63.81	20.43	67
68	65.03	19.88	64.94	20.16	64.85	20.45	64.76	20.73	68
69	65.99	20.17	65.90	20.46	65.81	20.75	65.72	21.04	69
70	66.94	20.47	66.85	20.76	66.76	21.05	66.67	21.34	70
71	67.90	20.76	67.81	21.05	67.71	21.35	67.62	21.65	71
72	68.85	21.05	68.76	21.35	68.67	21.65	68.57	21.95	72
73	69.81	21.34	69.72	21.65	69.62	21.95	69.52	22.26	73
74	70.77	21.64	70.67	21.94	70.58	22.25	70.43	22.56	74
75	71.72	21.93	71.63	22.24	71.53	22.55	71.43	22.86	75
76	72.68	22.22	72.58	22.54	72.48	22.85	72.38	23.17	76
77	73.64	22.51	73.54	22.83	73.44	23.15	73.33	23.47	77
78	74.59	22.80	74.49	23.13	74.39	23.46	74.29	23.78	78
79	75.55	23.10	75.45	23.43	75.34	23.76	75.24	24.08	79
80	76.50	23.39	76.40	23.72	76.30	24.06	76.19	24.39	80
81	77.46	23.68	77.36	24.02	77.25	24.36	77.14	24.69	81
82	78.42	23.97	78.31	24.32	78.20	24.66	78.10	25.00	82
83	79.37	24.27	79.27	24.61	79.16	25.96	79.05	25.30	83
84	80.33	24.56	80.22	24.91	80.11	25.26	80.00	25.61	84
85	81.29	24.85	81.18	25.21	81.07	25.56	80.95	25.91	85
86	82.24	25.14	82.13	25.50	82.02	25.86	81.91	26.22	86
87	83.20	25.44	83.09	25.80	82.97	26.16	82.86	26.52	87
88	84.15	25.73	84.04	26.10	83.93	26.46	83.81	26.83	88
89	85.11	26.02	85.00	26.39	84.88	26.76	84.76	27.13	89
90	86.07	26.31	85.95	26.69	85.83	27.06	85.72	27.44	90
91	87.02	26.61	86.91	26.99	86.79	27.36	86.67	27.74	91
92	87.98	26.90	87.86	27.28	87.74	27.66	87.62	28.05	92
93	88.94	27.19	88.82	27.58	88.70	27.97	88.57	28.35	93
94	89.89	27.48	89.77	27.87	89.65	28.27	89.53	28.66	94
95	90.85	27.78	90.73	28.17	90.60	28.57	90.48	28.96	95
96	91.81	28.07	91.68	28.47	91.56	28.87	91.43	29.27	96
97	92.76	28.36	92.64	28.76	92.51	29.17	92.38	29.57	97
98	93.72	28.65	93.59	29.06	93.46	29.47	93.33	29.88	98
99	94.67	28.94	94.55	29.36	94.42	29.77	94.29	30.18	99
100	95.63	29.24	95.50	29.65	95.37	30.07	95.24	30.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.31	0.95	0.31	0.95	0.32	0.95	0.32	1
2	1.90	0.62	1.90	0.63	1.90	0.63	1.89	0.64	2
3	2.85	0.93	2.85	0.94	2.84	0.95	2.84	0.96	3
4	3.80	1.24	3.80	1.25	3.79	1.27	3.79	1.29	4
5	4.76	1.55	4.75	1.57	4.74	1.59	4.73	1.61	5
6	5.71	1.85	5.70	1.88	5.69	1.90	5.68	1.93	6
7	6.66	2.16	6.65	2.19	6.64	2.22	6.63	2.25	7
8	7.61	2.47	7.60	2.51	7.59	2.54	7.58	2.57	8
9	8.56	2.78	8.55	2.82	8.53	2.86	8.52	2.89	9
10	9.51	3.09	9.50	3.13	9.48	3.17	9.47	3.21	10
11	10.46	3.40	10.45	3.44	10.43	3.49	10.42	3.54	11
12	11.41	3.71	11.40	3.76	11.38	3.81	11.36	3.86	12
13	12.36	4.02	12.35	4.07	12.33	4.12	12.31	4.18	13
14	13.31	4.33	13.30	4.38	13.28	4.44	13.26	4.50	14
15	14.27	4.64	14.25	4.70	14.22	4.76	14.20	4.82	15
16	15.22	4.94	15.20	5.01	15.17	5.08	15.15	5.14	16
17	16.17	5.25	16.14	5.32	16.12	5.39	16.10	5.46	17
18	17.12	5.56	17.09	5.64	17.07	5.71	17.04	5.79	18
19	18.07	5.87	18.04	5.95	18.02	6.03	17.99	6.11	19
20	19.02	6.18	18.99	6.26	18.97	6.35	18.94	6.43	20
21	19.97	6.49	19.94	6.58	19.91	6.66	19.89	6.75	21
22	20.92	6.80	20.89	6.89	20.86	6.98	20.83	7.07	22
23	21.87	7.11	21.84	7.20	21.81	7.30	21.78	7.39	23
24	22.83	7.42	22.79	7.52	22.76	7.62	22.73	7.71	24
25	23.78	7.73	23.74	7.83	23.71	7.93	23.67	8.04	25
26	24.73	8.03	24.69	8.14	24.66	8.25	24.62	8.36	26
27	25.68	8.34	25.64	8.46	25.60	8.57	25.57	8.68	27
28	26.63	8.65	26.59	8.77	26.55	8.88	26.51	9.00	28
29	27.58	8.96	27.54	9.08	27.50	9.20	27.46	9.32	29
30	28.53	9.27	28.49	9.39	28.45	9.52	28.41	9.64	30
31	29.48	9.58	29.44	9.71	29.40	9.84	29.35	9.96	31
32	30.43	9.89	30.39	10.02	30.35	10.15	30.30	10.29	32
33	31.38	10.20	31.34	10.33	31.29	10.47	31.25	10.61	33
34	32.34	10.51	32.29	10.65	32.24	10.79	32.20	10.93	34
35	33.29	10.82	33.24	10.96	33.19	11.11	33.14	11.25	35
36	34.24	11.12	34.19	11.27	34.14	11.42	34.09	11.57	36
37	35.19	11.43	35.14	11.59	35.09	11.74	35.04	11.89	37
38	36.14	11.74	36.09	11.90	36.04	12.06	35.98	12.21	38
39	37.09	12.05	37.04	12.21	36.98	12.37	36.93	12.54	39
40	38.04	12.36	37.99	12.53	37.93	12.69	37.88	12.86	40
41	38.99	12.67	38.94	12.84	38.88	13.01	38.82	13.18	41
42	39.94	12.98	39.89	13.15	39.83	13.33	39.77	13.50	42
43	40.90	13.29	40.84	13.47	40.78	13.64	40.72	13.82	43
44	41.85	13.60	41.79	13.78	41.73	13.96	41.66	14.14	44
45	42.80	13.91	42.74	14.09	42.67	14.28	42.61	14.46	45
46	43.75	14.21	43.69	14.41	43.62	14.60	43.56	14.79	46
47	44.70	14.52	44.64	14.72	44.57	14.91	44.51	15.11	47
48	45.65	14.83	45.59	15.03	45.52	15.23	45.45	15.43	48
49	46.60	15.14	46.54	15.35	46.47	15.55	46.40	15.75	49
50	47.55	15.45	47.48	15.66	47.42	15.87	47.35	16.07	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.50	15.76	48.43	15.97	48.36	16.18	48.29	16.39	51
52	49.45	16.07	49.38	16.28	49.31	16.50	49.24	16 71	52
53	50.41	16.38	50.33	16.60	50.26	16.82	50.19	17.04	53
54	51.36	16.69	51.28	16.91	51.21	17.13	51.13	17.36	54
55	52.31	17.00	52.23	17.22	52.16	17.45	52.08	17.68	55
56	53.26	17.30	53.18	17.54	53.11	17.77	53.03	18.00	56
57	54.21	17.61	54.13	17.85	54.05	18.09	53.98	18.32	57
58	55.16	17.92	55.08	18.16	55.00	18.40	54.92	18.64	58
59	56.11	18.23	56.03	18.48	55.95	18.72	55.87	18.96	59
60	57.06	18.54	56.98	18.79	56.90	19.04	56.82	19.29	60
61	58.01	18 85	57.93	19.10	57.85	19.36	57.76	19.61	61
62	58.97	19.16	58.88	19.42	58.80	19.67	58.71	19.93	62
63	59.92	19.47	59.83	19.73	59.74	19.99	59.66	20.25	63
64	60.87	19.78	60.78	20.04	60.69	20.31	60.60	20.57	64
65	61.82	20.09	61.73	20.36	61.64	20.62	61.55	20.89	65
66	62.77	20.40	62.68	20.67	62.59	20.94	62.50	21.22	66
67	63.72	20.70	63.63	20.98	63.54	21.26	63.44	21.54	67
68	64.67	21.01	64.58	21.30	64.49	21.58	64.39	21.86	68
69	65.62	21.32	65.53	21.61	65.43	21.89	65.34	22.18	69
70	66.57	21.63	66.48	21.92	66.38	22.21	66.29	22.50	70
71	67.53	21.94	67.43	22.23	67.33	22.53	67.23	22.82	71
72	68.48	22.25	68.38	22.55	68.28	22.85	68.18	23.14	72
73	69.43	22.56	69.33	22.86	69.23	23.16	69.13	23.47	73
74	70.38	22.87	70.28	23.17	70.18	23.48	70.07	23.79	74
75	71.33	23.18	71.23	23.49	71.12	23.80	71.02	24.11	75
76	72.28	23.49	72.18	23.80	72.07	24.12	71.97	24.43	76
77	73 23	23.79	73.13	24.11	73.02	24.43	72.91	24.75	77
78	74.18	24.10	74.08	24.43	73.97	24.75	73.86	25.07	78
79	75.13	24.41	75.03	24.74	74.92	25.07	74.81	25.39	79
80	76.08	24.72	75.98	25.05	75.87	25.38	75.75	25.72	80
81	77.04	25.03	76.93	25.37	76.81	25.70	76.70	26.04	81
82	77.99	25.34	77.88	25.68	77.76	26.02	77.65	26.36	82
83	78.94	25.65	78.83	25.99	78.71	26.34	78.60	26.68	83
84	79.89	25.96	79.77	26.31	79.66	26.65	79.54	27.00	84
85	80.84	26.27	80.72	26.62	80.61	26.97	80.49	27.32	85
86	81.79	26.58	81.67	26.93	81.56	27.29	81.44	27.64	86
87	82.74	26.88	82.62	27.25	82.50	27.61	82.38	27.97	87
88	83.69	27.19	83.57	27.56	83.45	27.92	83.33	28.29	88
89	84.64	27.50	84.52	27.87	84.40	28.24	84.28	28.61	89
90	85.60	27.81	85.47	28.18	85.35	28.56	85.22	28.93	90
91	86.55	28.12	86.42	28.50	86.30	28.87	86.17	29.25	91
92	87.50	28.43	87.37	28.81	87.25	29.19	87.12	29.57	92
93	88.45	28.74	88.32	29.12	88.19	29.51	88.06	29.89	93
94	89.40	29.05	89.27	29.44	89.14	29.83	89.01	30.22	94
95	90.35	29.36	90.22	29.75	90.09	30.14	89.96	30.54	95
96	91.30	29.67	91.17	30.06	91.04	30.46	90.91	30.86	96
97	92.25	29.97	92.12	30.38	91.99	30.78	91.85	31.18	97
98	93.20	30.28	93.07	30.69	92.94	31.10	92.80	31.50	98
99	94.15	30.59	94.02	31.00	93.88	31.41	93.75	31.82	99
100	95.11	30.90	94.97	31.32	94.83	31.73	94.69	32 14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.33	0.94	0.33	0.94	0.33	0.94	0.34	1
2	1.89	0.65	1.89	0.66	1.89	0.67	1.88	0.68	2
3	2.84	0.98	2.83	0.99	2.83	1.00	2.82	1.01	3
4	3.78	1.30	3.78	1.32	3.77	1.34	3.76	1.35	4
5	4.73	1.63	4.72	1.65	4.71	1.67	4.71	1.69	5
6	5.67	1.95	5.66	1.98	5.66	2.00	5.65	2.03	6
7	6.62	2.28	6.61	2.31	6.60	2.34	6.59	2.37	7
8	7.56	2.60	7.55	2.64	7.54	2.67	7.53	2.70	8
9	8.51	2.93	8.50	2.97	8.48	3.00	8.47	3.04	9
10	9.46	3.26	9.44	3.30	9.43	3.34	9.41	3.38	10
11	10.40	3.58	10.38	3.63	10.37	3.67	10.35	3.72	11
12	11.35	3.91	11.33	3.96	11.31	4.01	11.29	4.06	12
13	12.29	4.23	12.27	4.29	12.25	4.34	12.24	4.39	13
14	13.24	4.56	13.22	4.62	13.20	4.67	13.18	4.73	14
15	14.18	4.88	14.16	4.95	14.14	5.01	14.12	5.07	15
16	15.13	5.21	15.11	5.28	15.08	5.34	15.06	5.41	16
17	16.07	5.53	16.05	5.60	16.02	5.67	16.00	5.74	17
18	17.02	5.86	16.99	5.93	16.97	6.01	16.94	6.08	18
19	17.96	6.19	17.94	6.26	17.91	6.34	17.88	6.42	19
20	18.91	6.51	18.88	6.59	18.85	6.68	18.82	6.76	20
21	19.86	6.84	19.83	6.92	19.80	7.01	19.76	7.10	21
22	20.80	7.16	20.77	7.25	20.74	7.34	20.71	7.43	22
23	21.75	7.49	21.71	7.58	21.68	7.68	21.65	7.77	23
24	22.69	7.81	22.66	7.91	22.62	8.01	22.59	8.11	24
25	23.64	8.14	23.60	8.24	23.57	8.35	23.53	8.45	25
26	24.58	8.46	24.55	8.57	24.51	8.68	24.47	8.79	26
27	25.53	8.79	25.49	8.90	25.45	9.01	25.41	9.12	27
28	26.47	9.12	26.43	9.23	26.39	9.35	26.35	9.46	28
29	27.42	9.44	27.38	9.56	27.34	9.68	27.29	9.80	29
30	28.37	9.77	28.32	9.89	28.28	10.01	28.24	10.14	30
31	29.31	10.09	29.27	10.22	29.22	10.35	29.18	10.48	31
32	30.26	10.42	30.21	10.55	30.16	10.68	30.12	10.81	32
33	31.20	10.74	31.15	10.88	31.11	11.02	31.06	11.15	33
34	32.15	11.07	32.10	11.21	32.05	11.35	32.00	11.49	34
35	33.09	11.39	33.04	11.54	32.99	11.68	32.94	11.83	35
36	34.04	11.72	33.99	11.87	33.94	12.02	33.88	12.17	36
37	34.98	12.05	34.93	12.20	34.88	12.35	34.82	12.50	37
38	35.93	12.37	35.88	12.53	35.82	12.68	35.76	12.84	38
39	36.88	12.70	36.82	12.86	36.76	13.02	36.71	13.18	39
40	37.82	13.02	37.76	13.19	37.71	13.35	37.65	13.52	40
41	38.77	13.35	38.71	13.52	38.65	13.69	38.59	13.85	41
42	39.71	13.67	39.65	13.85	39.59	14.02	39.53	14.19	42
43	40.66	14.00	40.60	14.18	40.53	14.35	40.47	14.53	43
44	41.60	14.32	41.54	14.51	41.48	14.69	41.41	14.87	44
45	42.55	14.65	42.48	14.84	42.42	15.02	42.35	15.21	45
46	43.49	14.98	43.43	15.17	43.36	15.36	43.29	15.54	46
47	44.44	15.30	44.37	15.50	44.30	15.69	44.24	15.88	47
48	45.38	15.63	45.32	15.83	45.25	16.02	45.18	16.22	48
49	46.33	15.95	46.26	16.15	46.19	16.36	46.12	16.56	49
50	47.28	16.28	47.20	16.48	47.13	16.69	47.06	16.90	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.22	16.60	48.15	16.81	48.07	17.02	48.00	17.23	51
52	49.17	16.93	49.09	17.14	49.02	17.36	48.94	17.57	52
53	50.11	17.26	50.04	17.47	49.96	17.69	49.88	17.91	53
54	51.06	17.58	50.98	17.80	50.90	18.03	50.82	18.25	54
55	52.00	17.91	51.92	18.13	51.85	18.36	51.76	18.59	55
56	52.95	18.23	52.87	18.46	52.79	18.69	52.71	18.92	56
57	53.89	18.56	53.81	18.79	53.73	19.03	53.65	19.26	57
58	54.84	18.88	54.76	19.12	54.67	19.36	54.59	19.60	58
59	55.79	19.21	55.70	19.45	55.62	19.69	55.53	19.94	59
60	56.73	19.53	56.65	19.78	56.56	20.03	56.47	20.27	60
61	57.68	19.86	57.59	20.11	57.50	20.36	57.41	20.61	61
62	58.62	20.19	58.53	20.44	58.44	20.70	58.35	20.95	62
63	59.57	20.51	59.48	20.77	59.39	21.03	59.29	21.29	63
64	60.51	20.84	60.42	21.10	60.33	21.36	60.24	21.63	64
65	61.46	21.16	61.37	21.43	61.27	21.70	61.18	21.96	65
66	62.40	21.49	62.31	21.76	62.21	22.03	62.12	22.30	66
67	63.35	21.81	63.25	22.09	63.16	22.37	63.06	22.64	67
68	64.30	22.14	64.20	22.42	64.10	22.70	64.00	22.98	68
69	65.24	22.46	65.14	22.75	65.04	23.03	64.94	23.32	69
70	66.19	22.79	66.09	23.08	65.98	23.37	65.88	23.65	70
71	67.13	23.12	67.03	23.41	66.93	23.70	66.82	23.99	71
72	68.08	23.44	67.97	23.74	67.87	24.03	67.76	24.33	72
73	69.02	23.77	68.92	24.07	68.81	24.37	68.71	24.67	73
74	69.97	24.09	69.86	24.40	69.76	24.70	69.65	25.01	74
75	70.91	24.42	70.81	24.73	70.70	25.04	70.59	25.34	75
76	71.86	24.74	71.75	25.06	71.64	25.37	71.53	25.68	76
77	72.80	25.07	72.69	25.39	72.58	25.70	72.47	26.02	77
78	73.75	25.39	73.64	25.72	73.53	26.04	73.41	26.36	78
79	74.70	25.72	74.58	26.05	74.47	26.37	74.35	26.70	79
80	75.64	26.05	75.53	26.38	75.41	26.70	75.29	27.03	80
81	76.59	26.37	76.47	26.70	76.35	27.04	76.24	27.37	81
82	77.53	26.70	77.42	27.03	77.30	27.37	77.18	27.71	82
83	78.48	27.02	78.36	27.36	78.24	27.71	78.12	28.05	83
84	79.42	27.35	79.30	27.69	79.18	28.04	79.06	28.39	84
85	80.37	27.67	80.25	28.02	80.12	28.37	80.00	28.72	85
86	81.31	28.00	81.19	28.35	81.07	28.71	80.94	29.06	86
87	82.26	28.32	82.14	28.68	82.01	29.04	81.88	29.40	87
88	83.21	28.65	83.08	29.01	92.95	29.37	82.82	29.74	88
89	84.15	28.98	84.02	29.34	83.90	29.71	83.76	30.07	89
90	85.10	29.30	84.97	29.67	84.84	30.04	84.71	30.41	90
91	86.04	29.63	85.91	30.00	85.78	30.38	85.65	30.75	91
92	86.99	29.95	86.86	30.33	86.72	30.71	86.59	31.09	92
93	87.93	30.28	87.80	30.66	87.67	31.04	87.53	31.43	93
94	88.88	30.60	88.74	30.99	88.61	31.38	88.47	31.76	94
95	89.82	30.93	89.69	31.32	89.55	31.71	89.41	32.10	95
96	90.77	31.25	90.63	31.65	90.49	32.05	90.35	32.44	96
97	91.72	31.58	91.58	31.98	91.44	32.38	91.29	32.78	97
98	92.66	31.91	92.52	32.31	92.38	32.71	92.24	33.12	98
99	93.61	32.23	93.46	32.64	93.32	33.05	93.18	33.45	99
100	94.55	32.56	94.41	32.97	94.26	33.38	94.12	33.79	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.94	0.34	0.94	0.35	0.94	0.35	0.94	0.35	
2	1.88	0.68	1.88	0.69	1.87	0.70	1.87	0.71	2
3	2.82	1.03	2.81	1.04	2.81	1.05	2.81	1.06	3
4	3.76	1.37	3.75	1.38	3.75	1.40	3.74	1.42	4
5	4.70	1.71	4.69	1.73	4.68	1.75	4.68	1.77	5
6	5.64	2.05	5.63	2.08	5.62	2.10	5.61	2.13	6
7	6.58	2.39	6.57	2.42	6.56	2.45	6.55	2.48	7
8	7.52	2.74	7.51	2.77	7.49	2.80	7.48	2.83	8
9	8.46	3.08	8.44	3.12	8.43	3.15	8.42	3.19	9
10	9.40	3.42	9.38	3.46	9.37	3.50	9.35	3.54	10
11	10.34	3.76	10.32	3.81	10.30	3.85	10.29	3.90	11
12	11.28	4.10	11.26	4.15	11.24	4.20	11.22	4.25	12
13	12.22	4.45	12.20	4.50	12.18	4.55	12.16	4.61	13
14	13.16	4.79	13.13	4.85	13.11	4.90	13.09	4.96	14
15	14.10	5.13	14.07	5.19	14.05	5.25	14.03	5.31	15
16	15.04	5.47	15.01	5.54	14.99	5.60	14.96	5.67	16
17	15.97	5.81	15.95	5.88	15.92	5.95	15.90	6.02	17
18	16.91	6.16	16.89	6.23	16.86	6.30	16.83	6.38	18
19	17.85	6.50	17.83	6.58	17.80	6.65	17.77	6.73	19
20	18.79	6.84	18.76	6.92	18.73	7.00	18.70	7.09	20
21	19.73	7.18	19.70	7.27	19.67	7.35	19.64	7.44	21
22	20.67	7.52	20.64	7.61	20.61	7.70	20.57	7.79	22
23	21.61	7.87	21.58	7.96	21.54	8.05	21.51	8.15	23
24	22.55	8.21	22.52	8.31	22.48	8.40	22.44	8.50	24
25	23.49	8.55	23.45	8.65	23.42	8.76	23.38	8.86	25
26	24.43	8.89	24.39	9.00	24.35	9.11	24.31	9.21	26
27	25.37	9.23	25.33	9.35	25.29	9.46	25.25	9.57	27
28	26.31	9.58	26.27	9.69	26.23	9.81	26.18	9.92	28
29	27.25	9.92	27.21	10.04	27.16	10.16	27.12	10.27	29
30	28.19	10.26	28.15	10.38	28.10	10.51	28.05	10.63	30
31	29.13	10.60	29.08	10.73	29.04	10.86	28.99	10.98	31
32	30.07	10.94	30.02	11.08	29.97	11.21	29.92	11.34	32
33	31.01	11.29	30.96	11.42	30.91	11.56	30.86	11.69	33
34	31.95	11.63	31.90	11.77	31.85	11.91	31.79	12.05	34
35	32.89	11.97	32.84	12.11	32.78	12.26	32.73	12.40	35
36	33.83	12.31	33.77	12.46	33.72	12.61	33.66	12.75	36
37	34.77	12.65	34.71	12.81	34.66	12.96	34.60	13.11	37
38	35.71	13.00	35.65	13.15	35.59	13.31	35.54	13.46	38
39	36.65	13.34	36.59	13.50	36.53	13.66	36.47	13.82	39
40	37.59	13.68	37.53	13.84	37.47	14.01	37.41	14.17	40
41	38.53	14.02	38.47	14.19	38.40	14.36	38.34	14.53	41
42	39.47	14.36	39.40	14.54	39.34	14.71	39.28	14.88	42
43	40.41	14.71	40.34	14.88	40.28	15.06	40.21	15.23	43
44	41.35	15.05	41.28	15.23	41.21	15.41	41.15	15.59	44
45	42.29	15.39	42.22	15.58	42.15	15.76	42.08	15.94	45
46	43.23	15.73	43.16	15.92	43.09	16.11	43.02	16 30	46
47	44.17	16.07	44.09	16.27	44.02	16.46	43.95	16 65	47
48	45.11	16.42	45.03	16.61	44.96	16.81	44.89	17.01	48
49	46.04	16.76	45.97	16.96	45.90	17.16	45.82	17.36	49
50	46.98	17.10	46.91	17.31	46.83	17.51	46.76	17.71	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	70 Deg.		69¾ Deg.		69½ Deg.		69¼ Deg.		Distance.

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.92	17.44	47.35	17.65	47.77	17.86	47.69	18.07	51
52	48.86	17.79	48.79	18.00	48.71	18.21	48.63	18.42	52
53	49.80	18.13	49.72	18.34	49.64	18.56	49.56	18.78	53
54	50.74	18.47	50.66	18.69	50.58	18.91	50.50	19.13	54
55	51.68	18.81	51.60	19.04	51.52	19.26	51.43	19.49	55
56	52.62	19.15	52.54	19.38	52.45	19.61	52.37	19.84	56
57	53.56	19.50	53.48	19.73	53.39	19.96	53.30	20.19	57
58	54.50	19.84	54.42	20.07	54.33	20.31	54.24	20.55	58
59	55.44	20.18	55.35	20.42	55.26	20.66	55.17	20.90	59
60	56.38	20.52	56.29	20.77	56.20	21.01	56.11	21.26	60
61	57.32	20.86	57.23	21.11	57.14	21.36	57.04	21.61	61
62	58.26	21.21	58.17	21.46	58.07	21.71	57.98	21.97	62
63	59.20	21.55	59.11	21.81	59.01	22.06	58.91	22.32	63
64	60.14	21.89	60.04	22.15	59.95	22.41	59.85	22.67	64
65	61.08	22.23	60.98	22.50	60.88	22.76	60.78	23.03	65
66	62.02	22.57	61.92	22.84	61.82	23.11	61.72	23.38	66
67	62.96	22.92	62.86	23.19	62.76	23.46	62.65	23.74	67
68	63.90	23.26	63.80	23.54	63.69	23.81	63.59	24.09	68
69	64.84	23.60	64.74	23.88	64.63	24.16	64.52	24.45	69
70	65.78	23.94	65.67	24.23	65.57	24.51	65.46	24.80	70
71	66.72	24.28	66.61	24.57	66.50	24.86	66.39	25.15	71
72	67.66	24.63	67.55	24.92	67.44	25.21	67.33	25.51	72
73	68.60	24.97	68.49	25.27	68.38	25.57	68.26	25.86	73
74	69.54	25.31	69.43	25.61	69.31	25.92	69.20	26.22	74
75	70.48	25.65	70.36	25.96	70.25	26.27	70.14	26.57	75
76	71.42	25.99	71.30	26.30	71.19	26.62	71.07	26.93	76
77	72.36	26.34	72.24	26.65	72.12	26.97	72.01	27.28	77
78	73.30	26.68	73.18	27.00	73.06	27.32	72.94	27.63	78
79	74.24	27.02	74.12	27.34	74.00	27.67	73.88	27.99	79
80	75.18	27.36	75.06	27.69	74.93	28.02	74.81	28.34	80
81	76.12	27.70	75.99	28.04	75.87	28.37	75.75	28.70	81
82	77.05	28.05	76.93	28.38	76.81	28.72	76.68	29.05	82
83	77.99	28.39	77.87	28.73	77.74	29.07	77.62	29.41	83
84	78.93	28.73	78.81	29.07	78.68	29.42	78.55	29.76	84
85	79.87	29.07	79.75	29.42	79.62	29.77	79.49	30.11	85
86	80.81	29.41	80.68	29.77	80.55	30.12	80.42	30.47	86
87	81.75	29.76	81.62	30.11	81.49	30.47	81.36	30.82	87
88	82.69	30.10	82.56	30.46	82.43	30.82	82.29	31.18	88
89	83.63	30.44	83.50	30.80	83.36	31.17	83.23	31.53	89
90	84.57	30.78	84.44	31.15	84.30	31.52	84.16	31.89	90
91	85.51	31.12	85.38	31.50	85.24	31.87	85.10	32.24	91
92	86.45	31.47	86.31	31.84	86.17	32.22	86.03	32.59	92
93	87.39	31.81	87.25	32.19	87.11	32.57	86.97	32.95	93
94	88.33	32.15	88.19	32.54	88.05	32.92	87.90	33.30	94
95	89.27	32.49	89.13	32.88	88.98	33.27	88.84	33.66	95
96	90.21	32.83	90.07	33.23	89.92	33.62	89.77	34.01	96
97	91.15	33.18	91.00	33.57	90.86	33.97	90.71	34.37	97
98	92.09	33.52	91.94	33.92	91.79	34.32	91.64	34.72	98
99	93.03	33.86	92.88	34.27	92.73	34.67	92.58	35.07	99
100	93.97	34.20	93.82	34.61	93.67	35.02	93.51	35.43	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	70 Deg.		69¾ Deg.		69½ Deg		69¼ Deg		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.93	0.36	0.93	0.36	0.93	0.37	0.93	0.37	1
2	1.87	0.72	1.86	0.72	1.86	0.73	1.86	0.74	2
3	2.80	1.08	2.80	1.09	2.79	1.10	2.79	1.11	3
4	3.73	1.43	3.73	1.45	3.72	1.47	3.72	1.48	4
5	4.67	1.79	4.66	1.81	4.65	1.83	4.64	1.85	5
6	5.60	2.15	5.59	2.17	5.58	2.20	5.57	2.22	6
7	6.54	2.51	6.52	2.54	6.51	2.57	6.50	2.59	7
8	7.47	2.87	7.46	2.90	7.44	2.93	7.43	2.96	8
9	8.40	3.23	8.39	3.26	8.37	3.30	8.36	3.34	9
10	9.34	3.58	9.32	3.62	9.30	3.67	9.29	3.71	10
11	10.27	3.94	10.25	3.99	10.23	4.03	10.22	4.08	11
12	11.20	4.30	11.18	4.35	11.17	4.40	11.15	4.45	12
13	12.14	4.66	12.12	4.71	12.10	4.76	12.07	4.82	13
14	13.07	5.02	13.05	5.07	13.03	5.13	13.00	5.19	14
15	14.00	5.38	13.98	5.44	13.96	5.50	13.93	5.56	15
16	14.94	5.73	14.91	5.80	14.89	5.86	14.86	5.93	16
17	15.87	6.09	15.84	6.16	15.82	6.23	15.79	6.30	17
18	16.80	6.45	16.78	6.52	16.75	6.60	16.72	6.67	18
19	17.74	6.81	17.71	6.89	17.68	6.96	17.65	7.04	19
20	18.67	7.17	18.64	7.25	18.61	7.33	18.58	7.41	20
21	19.61	7.53	19.57	7.61	19.54	7.70	19.50	7.78	21
22	20.54	7.88	20.50	7.97	20.47	8.06	20.43	8.15	22
23	21.47	8.24	21.44	8.34	21.40	8.43	21.36	8.52	23
24	22.41	8.60	22.37	8.70	22.33	8.80	22.29	8.89	24
25	23.34	8.96	23.30	9.06	23.26	9.16	23.22	9.26	25
26	24.27	9.32	24.23	9.42	24.19	9.53	24.15	9.63	26
27	25.21	9.68	25.16	9.79	25.12	9.90	25.08	10.01	27
28	26.14	10.03	26.10	10.15	26.05	10.26	26.01	10.38	28
29	27.07	10.39	27.03	10.51	26.98	10.63	26.94	10.75	29
30	28.01	10.75	27.96	10.87	27.91	11.00	27.86	11.12	30
31	28.94	11.11	28.89	11.24	28.84	11.36	28.79	11.49	31
32	29.87	11.47	29.82	11.60	29.77	11.73	29.72	11.86	32
33	30.81	11.83	30.76	11.96	30.70	12.09	30.65	12.23	33
34	31.74	12.18	31.69	12.32	31.63	12.46	31.58	12.60	34
35	32.68	12.54	32.62	12.69	32.56	12.83	32.51	12.97	35
36	33.61	12.90	33.55	13.05	33.50	13.19	33.44	13.34	36
37	34.54	13.26	34.48	13.41	34.43	13.56	34.37	13.71	37
38	35.48	13.62	35.42	13.77	35.36	13.93	35.29	14.08	38
39	36.41	13.98	36.35	14.14	36.29	14.29	36.22	14.45	39
40	37.34	14.33	37.28	14.50	37.22	14.66	37.15	14.82	40
41	38.28	14.69	38.21	14.86	38.15	15.03	38.08	15.19	41
42	39.21	15.05	39.14	15.22	39.08	15.39	39.01	15.56	42
43	40.14	15.41	40.08	15.58	40.01	15.76	39.94	15.93	43
44	41.08	15.77	41.01	15.95	40.94	16.13	40.87	16.30	44
45	42.01	16.13	41.94	16.31	41.87	16.49	41.80	16.68	45
46	42.94	16.48	42.87	16.67	42.80	16.86	42.73	17.05	46
47	43.88	16.84	43.80	17.03	43.73	17.23	43.65	17.42	47
48	44.81	17.20	44.74	17.40	44.66	17.59	44.58	17.79	48
49	45.75	17.56	45.67	17.76	45.59	17.96	45.51	18.16	49
50	46.68	17.92	46.60	18.12	46.52	18.33	46.44	18.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg		68½ Deg.		68¼ Deg.		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.61	18.28	47.53	18.48	47.45	18.69	47.37	18.90	51
52	48.55	18.64	48.46	18.85	48.38	19.06	48.30	19.27	52
53	49.48	18.99	49.40	19.21	49.31	19.42	49.23	19.64	53
54	50.41	19.35	50.33	19.57	50.24	19.79	50.16	20.01	54
55	51 35	19.71	51.26	19.93	51.17	20.16	51.08	20.38	55
56	52 28	20.07	52.19	20.30	52.10	20.52	52.01	20.75	56
57	53 21	20.43	53.12	20.66	53.03	20.89	52.94	21.12	57
58	54.15	20.79	54.06	21.02	53.96	21.26	53.87	21.49	58
59	55.08	21.14	54.99	21.38	54.89	21.62	54.80	21.86	59
60	56.01	21.50	55.92	21.75	55.83	21.99	55.73	22.23	60
61	56.95	21.86	56.85	22.11	56.76	22.36	56.66	22.60	61
62	57 88	22.22	57.78	22.47	57.69	22.72	57.59	22.97	62
63	58.82	22.58	58.72	22.83	58.62	23.09	58.52	23.35	63
64	59.75	22.94	59.65	23.20	59.55	23.46	59.44	23.72	64
65	60.68	23.29	60.58	23.56	60.48	23.82	60.37	24.09	65
66	61.62	23.65	61.51	23.92	61.41	24.19	61.30	24.46	66
67	62.55	24.01	62.44	24.28	62.34	24.56	62.23	24.83	67
68	63.48	24.37	63.38	24.65	63.27	24.92	63.16	25.20	68
69	64.42	24.73	64.31	25.01	64.20	25.29	64.09	25.57	69
70	65.35	25.09	65.24	25.37	65.13	25.66	65.02	25.94	70
71	66.28	25.44	66.17	25.73	66.06	26.02	65.95	26.31	71
72	67.22	25.80	67.10	26.10	66.99	26.39	66.87	26.68	72
73	68.15	26.16	68.04	26.46	67.92	26.75	67.80	27.05	73
74	69.08	26.52	68.97	26.82	68.85	27.12	68.73	27.42	74
75	70.02	26.88	69.90	27.18	69.78	27.49	69.66	27.79	75
76	70.95	27.24	70.83	27.55	70.71	27.85	70.59	28.16	76
77	71.89	27.59	71.76	27.91	71.64	28.22	71.52	28.53	77
78	72.82	27.95	72.70	28.27	72.57	28.59	72.45	28.90	78
79	73.75	28.31	73.63	28.63	73.50	28.95	73.38	29.27	79
80	74.69	28.67	74.56	29.00	74.43	29.32	74.30	29.64	80
81	75.62	29.03	75.49	29.36	75.36	29.69	75.23	30.02	81
82	76.55	29.39	76.42	29.72	76.29	30.05	76.16	30.39	82
83	77.49	29.74	77.36	30.08	77.22	30.42	77.09	30.76	83
84	78.42	30.10	78.29	30.44	78.16	30.79	78.02	31.13	84
85	79.35	30.46	79.22	30.81	79.09	31.15	78.95	31.50	85
86	80.29	30.82	80.15	31.17	80.02	31.52	79.88	31.87	86
87	81.22	31.18	81.08	31.53	80.95	31.89	80.81	32.24	87
88	82.16	31 54	82.02	31.89	81.88	32.25	81.74	32.61	88
89	83.09	31.89	82.95	32.26	82.81	32.62	82.66	32.98	89
90	84.02	32.25	83.88	32.62	83.74	32.99	83.59	33.35	90
91	84.96	32.61	84.81	32.98	84.67	33.35	84.52	33.72	91
92	85.89	32.97	85.74	33.34	85.60	33.72	85.45	34.09	92
93	86.82	33.33	86.68	33.71	86.53	34.08	86.38	34.46	93
94	87.76	33.69	87.61	34.07	87.46	34.45	87.31	34.83	94
95	88.69	34.04	88.54	34.43	88.39	34.82	88.24	35.20	95
96	89.62	34.40	89.47	34.79	89.32	35.18	89.17	35.57	96
97	90.56	34.76	90.40	35.16	90.25	35.55	90.09	35.94	97
98	91.49	35.12	91.34	35.52	91.18	35.92	91.02	36.31	98
99	92.42	35.48	92.27	35.88	92.11	36.28	91.95	36 69	99
100	93.36	35.84	93.20	36.24	93.04	36.65	92.88	37.06	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg.		68½ Deg.		68¼ Dog		

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.93	0.37	0.93	0.38	0.92	0.38	0.92	0.39	1
2	1.85	0.75	1.85	0.76	1.85	0.77	1.84	0.77	2
3	2.78	1.12	2.78	1.14	2.77	1.15	2.77	1.16	3
4	3.71	1.50	3.70	1.51	3.70	1.53	3.69	1.55	4
5	4.64	1.87	4.63	1.89	4.62	1.91	4.61	1.93	5
6	5.56	2.25	5.55	2.27	5.54	2.30	5.53	2.32	6
7	6.49	2.62	6.48	2.65	6.47	2.68	6.46	2.71	7
8	7.42	3.00	7.40	3.03	7.39	3.06	7.38	3.09	8
9	8.34	3.37	8.33	3.41	8.31	3.44	8.30	3.48	9
10	9.27	3.75	9.26	3.79	9.24	3.83	9.22	3.87	10
11	10.20	4.12	10.18	4.17	10.16	4.21	10.14	4.25	11
12	11.13	4.50	11.11	4.54	11.09	4.59	11.07	4.64	12
13	12.05	4.87	12.03	4.92	12.01	4.97	11.99	5.03	13
14	12.98	5.24	12.96	5.30	12.93	5.36	12.91	5.41	14
15	13.91	5.62	13.88	5.68	13.86	5.74	13.83	5.80	15
16	14.83	5.99	14.81	6.06	14.78	6.12	14.76	6.19	16
17	15.76	6.37	15.73	6.44	15.71	6.51	15.68	6.57	17
18	16.69	6.74	16.66	6.82	16.63	6.89	16.60	6.96	18
19	17.62	7.12	17.59	7.19	17.55	7.27	17.52	7.35	19
20	18.54	7.49	18.51	7.57	18.48	7.65	18.44	7.73	20
21	19.47	7.87	19.44	7.95	19.40	8.04	19.37	8.12	21
22	20.40	8.24	20.36	8.33	20.33	8.42	20.29	8.51	22
23	21.33	8.62	21.29	8.71	21.25	8.80	21.21	8.89	23
24	22.25	8.99	22.21	9.09	22.17	9.18	22.13	9.28	24
25	23.18	9.37	23.14	9.47	23.10	9.57	23.05	9.67	25
26	24.11	9.74	24.06	9.84	24.02	9.95	23.98	10.05	26
27	25.03	10.11	24.99	10.22	24.94	10.33	24.90	10.44	27
28	25.96	10.49	25.92	10.60	25.87	10.72	25.82	10.83	28
29	26.89	10.86	26.84	10.98	26.79	11.10	26.74	11.21	29
30	27.82	11.24	27.77	11.36	27.72	11.48	27.67	11.60	30
31	28.74	11.61	28.69	11.74	28.64	11.86	28.59	11.99	31
32	29.67	11.99	29.62	12.12	29.56	12.25	29.51	12.37	32
33	30.60	12.36	30.54	12.50	30.49	12.63	30.43	12.76	33
34	31.52	12.74	31.47	12.87	31.41	13.01	31.35	13.15	34
35	32.45	13.11	32.39	13.25	32.34	13.39	32.28	13.53	35
36	33.38	13.49	33.32	13.63	33.26	13.78	33.20	13.92	36
37	34.31	13.86	34.24	14.01	34.18	14.16	34.12	14.31	37
38	35.23	14.24	35.17	14.39	35.11	14.54	35.04	14.70	38
39	36.16	14.61	36.10	14.77	36.03	14.92	35.97	15.08	39
40	37.09	14.98	37.02	15.15	36.96	15.31	36.89	15.47	40
41	38.01	15.36	37.95	15.52	37.88	15.69	37.81	15.86	41
42	38.94	15.73	38.87	15.90	38.80	16.07	38.73	16.24	42
43	39.87	16.11	39.80	16.28	39.73	16.46	39.65	16.63	43
44	40.80	16.48	40.72	16.66	40.65	16.84	40.58	17.02	44
45	41.72	16.86	41.65	17.04	41.57	17.22	41.50	17.40	45
46	42.65	17.23	42.57	17.42	42.50	17.60	42.42	17.79	46
47	43.58	17.61	43.50	17.80	43.42	17.99	43.34	18.18	47
48	44.50	17.98	44.43	18.18	44.35	18.37	44.27	18.56	48
49	45.43	18.36	45.35	18.55	45.27	18.75	45.19	18.95	49
50	46.36	18.73	46.28	18.93	46.19	19.13	46.11	19.34	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	68 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.		

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.29	19.10	47.20	19.31	47.12	19.52	47.03	19.72	51
52	48.21	19.48	48.13	19.69	48.04	19.90	47.95	20.11	52
53	49.14	19.85	49.05	20.07	48.97	20.28	48.88	20.50	53
54	50.07	20.23	49.98	20.45	49.89	20.66	49.80	20.88	54
55	51.00	20.60	50.90	20.83	50.81	21.05	50.72	21.27	55
56	51.92	20.98	51.83	21.20	51.74	21.43	51.64	21.66	56
57	52.85	21.35	52.76	21.58	52.66	21.81	52.57	22.04	57
58	53.78	21.73	53.68	21.96	53.59	22.20	53.49	22.43	58
59	54.70	22.10	54.61	22.34	54.51	22.58	54.41	22.82	59
60	55.63	22.48	55.53	22.72	55.43	22.96	55.33	23.20	60
61	56.56	22.85	56.47	23.10	56.36	23.34	56.25	23.59	61
62	57.49	23.23	57.38	23.48	57.28	23.73	57.18	23.98	62
63	58.41	23.60	58.31	23.85	58.20	24.11	58.10	24.36	63
64	59.34	23.97	59.23	24.23	59.13	24.49	59.02	24.75	64
65	60.27	24.35	60.16	24.61	60.05	24.87	59.94	25.14	65
66	61.19	24.72	61.09	24.99	60.98	25.26	60.87	25.52	66
67	62.12	25.10	62.01	25.37	61.90	25.64	61.79	25.91	67
68	63.05	25.47	62.94	25.75	62.82	26.02	62.71	26.30	68
69	63.98	25.85	63.86	26.13	63.75	26.41	63.63	26.68	69
70	64.90	26.22	64.79	26.51	64.67	26.79	64.55	27.07	70
71	65.83	26.60	65.71	26.88	65.60	27.17	65.48	27.46	71
72	66.76	26.97	66.64	27.26	66.52	27.55	66.40	27.84	72
73	67.68	27.35	67.56	27.64	67.44	27.94	67.32	28.23	73
74	68.61	27.72	68.49	28.02	68.37	28.32	68.24	28.62	74
75	69.54	28.10	69.42	28.40	69.29	28.70	69.17	29.00	75
76	70.47	28.47	70.34	28.78	70.21	29.08	70.09	29.39	76
77	71.39	28.84	71.27	29.16	71.14	29.47	71.01	29.78	77
78	72.32	29.22	72.19	29.53	72.06	29.85	71.93	30.16	78
79	73.25	29.59	73.12	29.91	72.99	30.23	72.85	30.55	79
80	74.17	29.97	74.04	30.29	73.91	30.61	73.78	30.94	80
81	75.10	30.34	74.97	30.67	74.83	31.00	74.70	31.32	81
82	76.03	30.72	75.89	31.05	75.76	31.38	75.62	31.71	82
83	76.96	31.09	76.82	31.43	76.68	31.76	76.54	32.10	83
84	77.88	31.47	77.75	31.81	77.61	32.15	77.46	32.48	84
85	78.81	31.84	78.67	32.19	78.53	32.53	78.39	32.87	85
86	79.74	32.22	79.60	32.56	79.45	32.91	79.31	33.26	86
87	80.66	32.59	80.52	32.94	80.38	33.29	80.23	33.64	87
88	81.59	32.97	81.45	33.32	81.30	33.68	81.15	34.03	88
89	82.52	33.34	82.37	33.70	82.23	34.06	82.08	34.42	89
90	83.45	33.71	83.30	34.08	83.15	34.44	83.00	34.80	90
91	84.37	34.09	84.22	34.46	84.07	34.82	83.92	35.19	91
92	85.30	34.46	85.15	34.84	85.00	35.21	84.84	35.58	92
93	86.23	34.84	86.08	35.21	85.92	35.59	85.76	35.96	93
94	87.16	35.21	87.00	35.59	86.84	35.97	86.69	36.35	94
95	88.08	35.59	87.93	35.97	87.77	36.35	87.61	36.74	95
96	89.01	35.96	88.85	36.35	88.69	36.74	88.53	37.12	96
97	89.94	36.34	89.78	36.73	89.62	37.12	89.45	37.51	97
98	90.86	36.71	90.70	37.11	90.54	37.50	90.38	37.90	98
99	91.79	37.09	91.63	37.49	91.46	37.89	91.30	38.28	99
100	92.72	37.46	92.55	37.86	92.39	38.27	92.22	38.67	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	68 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.		

Distance.	23 Deg.		23¼ Deg.		23½ Deg.		23¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.92	0.39	0.92	0.39	0.92	0.40	0.92	0.40	1
2	1.84	0.78	1.84	0.79	1.83	0.80	1.83	0.81	2
3	2.76	1.17	2.76	1.18	2.75	1.20	2.75	1.21	3
4	3.68	1.56	3.68	1.58	3.67	1.59	3.66	1.61	4
5	4.30	1.95	4.59	1.97	4.59	1.99	4.58	2.01	5
6	5.52	2.34	5.51	2.37	5.50	2.39	5.49	2.42	6
7	6.44	2.74	6.43	2.76	6.42	2.79	6.41	2.82	7
8	7.36	3.13	7.35	3.16	7.34	3.19	7.32	3.22	8
9	8.28	3.52	8.27	3.55	8.25	3.59	8.24	3.62	9
10	9.20	3.91	9.19	3.95	9.17	3.99	9.15	4.03	10
11	10.13	4.30	10.11	4.34	10.09	4.39	10.07	4.43	11
12	11.05	4.69	11.03	4.74	11.00	4.78	10.98	4.83	12
13	11.97	5.08	11.94	5.13	11.92	5.18	11.90	5.24	13
14	12.89	5.47	12.86	5.53	12.84	5.58	12.81	5.64	14
15	13.81	5.86	13.78	5.92	13.76	5.98	13.73	6.04	15
16	14.73	6.25	14.70	6.32	14.67	6.38	14.64	6.44	16
17	15.65	6.64	15.62	6.71	15.59	6.78	15.56	6.85	17
18	16.57	7.03	16.54	7.11	16.51	7.18	16.48	7.25	18
19	17.49	7.42	17.46	7.50	17.42	7.58	17.39	7.65	19
20	18.41	7.81	18.38	7.89	18.34	7.97	18.31	8.05	20
21	19.33	8.21	19.29	8.29	19.26	8.37	19.22	8.46	21
22	20.25	8.60	20.21	8.68	20.18	8.77	20.14	8.86	22
23	21.17	8.99	21.13	9.08	21.09	9.17	21.05	9.26	23
24	22.09	9.38	22.05	9.47	22.01	9.57	21.97	9.67	24
25	23.01	9.77	22.97	9.87	22.93	9.97	22.88	10.07	25
26	23.93	10.16	23.89	10.26	23.84	10.37	23.80	10.47	26
27	24.85	10.55	24.81	10.66	24.76	10.77	24.71	10.87	27
28	25.77	10.94	25.73	11.05	25.68	11.16	25.63	11.28	28
29	26.69	11.33	26.64	11.45	26.59	11.56	26.54	11.68	29
30	27.62	11.72	27.56	11.84	27.51	11.96	27.46	12.08	30
31	28.54	12.11	28.48	12.24	28.43	12.36	28.37	12.49	31
32	29.46	12.50	29.40	12.63	29.35	12.76	29.29	12.89	32
33	30.38	12.89	30.32	13.03	30.26	13.16	30.21	13.29	33
34	31.30	13.28	31.24	13.42	31.18	13.56	31.12	13.69	34
35	32.22	13.68	32.16	13.82	32.10	13.96	32.04	14.10	35
36	33.14	14.07	33.08	14.21	33.01	14.35	32.95	14.50	36
37	34.06	14.46	34.00	14.61	33.93	14.75	33.87	14.90	37
38	34.98	14.85	34.91	15.00	34.85	15.15	34.78	15.30	38
39	35.90	15.24	35.83	15.39	35.77	15.55	35.70	15.71	39
40	36.82	15.63	36.75	15.79	36.68	15.95	36.61	16.11	40
41	37.74	16.02	37.67	16.18	37.60	16.35	37.53	16.51	41
42	38.66	16.41	38.59	16.58	38.52	16.75	38.44	16.92	42
43	39.58	16.80	39.51	16.97	39.43	17.15	39.36	17.32	43
44	40.50	17.19	40.43	17.37	40.35	17.54	40.27	17.72	44
45	41.42	17.58	41.35	17.76	41.27	17.94	41.19	18.12	45
46	42.34	17.97	42.26	18.16	42.18	18.34	42.10	18.53	46
47	43.26	18.36	43.18	18.55	43.10	18.74	43.02	18.93	47
48	44.18	18.76	44.10	18.95	44.02	19.14	43.93	19.33	48
49	45.10	19.15	45.02	19.34	44.94	19.54	44.85	19.73	49
50	46.03	19.54	45.94	19.74	45.85	19.94	45.77	20.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	67 Deg		66¾ Deg.		66½ Deg.		66¼ Deg.		

Distance.	23 Deg.		23¼ Deg.		23½ Deg.		23¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.95	19.93	46.86	20.13	46.77	20.34	46.68	20.54	51
52	47 87	20.32	47.78	20.53	47.69	20.73	47.60	20.94	52
53	48.79	20.71	48.70	20.92	48.60	21.13	48.51	21.35	53
54	49.71	21.10	49.61	21.32	49.52	21.53	49.43	21.75	54
55	50.63	21.49	50.53	21.71	50.44	21.93	50.34	22.15	55
56	51.55	21.88	51.45	22.11	51.36	22.33	51.26	22.55	56
57	52.47	22.27	52.37	22.50	52.27	22.73	52.17	22.96	57
58	53.39	22.66	53.29	22.90	53.19	23.13	53.09	23.36	58
59	54.31	23.05	54.21	23.29	54.11	23.53	54 00	23.76	59
60	55.23	23.44	55.13	23.68	55.02	23.92	54.92	24.16	60
61	56.15	23.83	56.05	24.08	55.94	24.32	55.83	24.57	61
62	57.07	24.23	56.97	24 47	56.86	24.72	56.75	24.97	62
63	57.99	24.62	57.88	24.87	57.77	25.12	57.66	25.37	63
64	58.91	25.01	58.80	25.26	58.69	25.52	58.58	25.78	64
65	59.83	25.40	59.72	25.66	59.61	25.92	59.50	26.18	65
66	60.75	25.79	60.64	26.05	60.53	26.32	60.41	26.58	66
67	61.67	26.18	61.56	26.45	61.44	26.72	61.33	26.98	67
68	62.59	26.57	62.48	26.84	62.36	27.11	62.24	27.39	68
69	63.51	26.96	63.40	27.24	63.28	27.51	63.16	27.79	69
70	64.44	27.35	64.32	27.63	64.19	27.91	64.07	28.19	70
71	65.36	27.74	65.23	28.03	65.11	28.34	64.99	28.59	71
72	66.28	28.13	66.15	28.42	66.03	28.71	65.90	29.00	72
73	67.20	28.52	67.07	28.82	66.95	29.11	66.82	29.40	73
74	68.12	28.91	67.99	29.21	67.86	29.51	67.73	29.80	74
75	69.04	29.30	68.91	29.61	68.78	29.91	68.65	30.21	75
76	69.96	29.70	69.83	30.00	69.70	30.30	69.56	30.61	76
77	70.88	30.09	70.75	30.40	70.61	30.70	70.48	31.01	77
78	71.80	30.48	71.67	30.79	71.53	31.10	71.39	31.41	78
79	72.72	30.87	72.58	31.18	72.45	31.50	72.31	31.82	79
80	73.64	31.26	73.50	31.58	73.36	31.90	73.22	32.22	80
81	74.56	31.65	74.42	31.97	74.28	32.30	74.14	32.62	81
82	75.48	32.04	75.34	32.37	75.20	32.70	75.06	33.03	82
83	76.40	32.43	76.26	32.76	76.12	33.10	75.97	33.43	83
84	77.32	32.82	77.18	33.16	77.03	33.49	76.89	33.83	84
85	78.24	33.21	78.10	33.55	77.95	33.89	77.80	34.23	85
86	79.16	33.60	79.02	33.95	78.87	34.29	78.72	34.64	86
87	80.08	33.99	79.93	34.34	79.78	34.69	79.63	35.04	87
88	81.00	34.38	80.85	34.74	80.70	35.09	80.55	35.44	88
89	81.92	34.78	81.77	35.13	81.62	35.49	81.46	35.84	89
90	82.85	35.17	82.69	35.53	82.54	35.89	82.38	36.25	90
91	83.77	35.56	83.61	35.92	83.45	36.29	83.29	36.65	91
92	84.69	35.95	84.53	36.32	84.37	36.68	84.21	37.05	92
93	85.61	36.34	85.45	36.71	85.29	37.08	85.12	37.46	93
94	86.53	36.73	86.37	37.11	86.20	37.48	86.04	37.86	94
95	87.45	37.12	87.29	37.50	87.12	37.88	86.95	38.26	95
96	88.37	37.51	88.20	37.90	88.04	38.28	87.87	38.66	96
97	89.29	37.90	89.12	38.29	88.95	38.68	88.79	39.07	97
98	90.21	38.29	90.04	38.68	89.87	39.08	89.70	39.47	98
99	91.13	38.68	90.96	39.08	90.79	39.48	90.62	39.87	99
100	92.05	39.07	91.88	39.47	91.71	39.87	91.53	40.27	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Distance.
	67 Deg.		66¾ Deg.		66½ Deg.		66¼ Deg.		

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.91	0.41	0.91	0.41	0.91	0.41	0.91	0.42	1
2	1.83	0.81	1.82	0.82	1.82	0.83	1.82	0.84	2
3	2.74	1.22	2.74	1.23	2.73	1.24	2 72	1.26	3
4	3.65	1.63	3.65	1.64	3.64	1.66	3.63	1.67	4
5	4.57	2.03	4.56	2.05	4.55	2.07	4.54	2.09	5
6	5.48	2.44	5.47	2.46	5.46	2.49	5.45	2.51	6
7	6.39	2.85	6.38	2.87	6.37	2.90	6.36	2.93	7
8	7.31	3.25	7.29	3.29	7.28	3.32	7.27	3.35	8
9	8.22	3.66	8.21	3.70	8.19	3.73	8.17	3.77	9
10	9.14	4.07	9.12	4.11	9.10	4.15	9.08	4.19	10
11	10.05	4.47	10.03	4.52	10.01	4.56	9.99	4.61	11
12	10.96	4.88	10.94	4.93	10.92	4.98	10.90	5.02	12
13	11.88	5.29	11.85	5.34	11.83	5.39	11.81	5.44	13
14	12.79	5.69	12.76	5.75	12.74	5.81	12.71	5.86	14
15	13.70	6.10	13.68	6.16	13.65	6.22	13.62	6.28	15
16	14.62	6.51	14.59	6.57	14.56	6.64	14.53	6.70	16
17	15.53	6.92	15.50	6.98	15.47	7.05	15.44	7.12	17
18	16.44	7.32	16.41	7.39	16.38	7.46	16.35	7.54	18
19	17.36	7.73	17.32	7.80	17.29	7.88	17.25	7.95	19
20	18.27	8.13	18.24	8.21	18.20	8.29	18.16	8.37	20
21	19.18	8.54	19.15	8.63	19.11	8.71	19.07	8.79	21
22	20.10	8.95	20.06	9.04	20.02	9.12	19.98	9.21	22
23	21.01	9.35	20.97	9.45	20.93	9.54	20.89	9.63	23
24	21.93	9.76	21.88	9.86	21.84	9.95	21.80	10.05	24
25	22.84	10.17	22.79	10.27	22.75	10.37	22.70	10.47	25
26	23.75	10.58	23.71	10.68	23.66	10.78	23.61	10.89	26
27	24.67	10.98	24.62	11.09	24.57	11.20	24.52	11.30	27
28	25.58	11.39	25.53	11.50	25.48	11.61	25.43	11.72	28
29	26.49	11.80	26.44	11.91	26.39	12.03	26.34	12.14	29
30	27.41	12.20	27.35	12.32	27.30	12.44	27.24	12.56	30
31	28.32	12.61	28.26	12.73	28.21	12.86	28.15	12.98	31
32	29.23	13.02	29.18	13.14	29.12	13.27	29.06	13.40	32
33	30.15	13.42	30.09	13.55	30.03	13.68	29.97	13.82	33
34	31.06	13.83	31.00	13.96	30.94	14.10	30.88	14.23	34
35	31.97	14.24	31.91	14.38	31.85	14.51	31.78	14.65	35
36	32.89	14.64	32.82	14.79	32.76	14.93	32.69	15.07	36
37	33.80	15.05	33.74	15.20	33.67	15.34	33.60	15.49	37
38	34.71	15.46	34.65	15.61	34.58	15.76	34.51	15.91	38
39	35.63	15.86	35.56	16.02	35.49	16.17	35.42	16.33	39
40	36.54	16.27	36.47	16.43	36.40	16.59	36.33	16.75	40
41	37.46	16.68	37.38	16.84	37.31	17.00	37.23	17.16	41
42	38.37	17.08	38.29	17.25	38.22	17.42	38.14	17.58	42
43	39.28	17.49	39.21	17.66	39.13	17.83	39.05	18.00	43
44	40.20	17.90	40.12	18.07	40.04	18.25	39.96	18.42	44
45	41.11	18 30	41.03	18.48	40.95	18.66	40.87	18.84	45
46	42.02	18.71	41.94	18.89	41.86	19.08	41.77	19.26	46
47	42.94	19.12	42.85	19.30	42.77	19.49	42.68	19.68	47
48	43.85	19.52	43.76	19.71	43.68	19.91	43.59	20.10	48
49	44.76	19.93	44.68	20.13	44.59	20.32	44.50	20.51	49
50	45.68	20.34	45.59	20.54	45.50	20.73	45.41	20.93	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg		

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.59	20.74	46.50	20.95	46.41	21.15	46.32	21.35	51
52	47.50	21.15	47.41	21.36	47.32	21.56	47.22	21.77	52
53	48.42	21.56	48.32	21.77	48.23	21.98	48.13	22.19	53
54	49.33	21.96	49.24	22.18	49.14	22.39	49.04	22.61	54
55	50.24	22.37	50.15	22.59	50.05	22.81	49.95	23.03	55
56	51.16	22.78	51.06	23.00	50.96	23.22	50.86	23.44	56
57	52.07	23.18	51.97	23.41	51.87	23.64	51.76	23.86	57
58	52.99	23.59	52.88	23.82	52.78	24.05	52.67	24.28	58
59	53.90	24.00	53.79	24.23	53.69	24.47	53.58	24.70	59
60	54.81	24.40	54.71	24.64	54.60	24.88	54.49	25.12	60
61	55.73	24.81	55.62	25.05	55.51	25.30	55.40	25.54	61
62	56.64	25.22	56.53	25.46	56.42	25.71	56.30	25.96	62
63	57.55	25.62	57.44	25.88	57.33	26.13	57.21	26.38	63
64	58.47	26.03	58.35	26.29	58.24	26.54	58.12	26.79	64
65	59.38	26.44	59.26	26.70	59.15	26.96	59.03	27.21	65
66	60.29	26.84	60.18	27.11	60.06	27.37	59.94	27.63	66
67	61.21	27.25	61.09	27.52	60.97	27.78	60.85	28.05	67
68	62.12	27.66	62.00	27.93	61.88	28.20	61.75	28.47	68
69	63.03	28.06	62.91	28.34	62.79	28.61	62.66	28.89	69
70	63.95	28.47	63.82	28.75	63.70	29.03	63.57	29.31	70
71	64.86	28.88	64.74	29.16	64.61	29.44	64.48	29.72	71
72	65.78	29.28	65.65	29.57	65.52	29.86	65.39	30.14	72
73	66.69	29.69	66.56	29.98	66.43	30.27	66.29	30.56	73
74	67.60	30.10	67.47	30.39	67.34	30.69	67.20	30.98	74
75	68.52	30.51	68.38	30.80	68.25	31.10	68.11	31.40	75
76	69.43	30.91	69.29	31.21	69.16	31.52	69.02	31.82	76
77	70.34	31.32	70.21	31.63	70.07	31.93	69.93	32.24	77
78	71.26	31.73	71.12	32.04	70.98	32.35	70.84	32.66	78
79	72.17	32.13	72.03	32.45	71.89	32.76	71.74	33.07	79
80	73.08	32.54	72.94	32.86	72.80	33.18	72.65	33.49	80
81	74.00	32.95	73.85	33.27	73.71	33.59	73.56	33.91	81
82	74.91	33.35	74.76	33.68	74.62	34.00	74.47	34.33	82
83	75.82	33.76	75.68	34.09	75.53	34.42	75.38	34.75	83
84	76.74	34.17	76.59	34.50	76.44	34.83	76.28	35.17	84
85	77.65	34.57	77.50	34.91	77.35	35.25	77.19	35.59	85
86	78.56	34.98	78.41	35.32	78.26	35.66	78.10	36.00	86
87	79.48	35.39	79.32	35.73	79.17	36.08	79.01	36.42	87
88	80.39	35.79	80.24	36.14	80.08	36.49	79.92	36.84	88
89	81.31	36.20	81.15	36.55	80.99	36.91	80.82	37.26	89
90	82.22	36.61	82.06	36.96	81.90	37.32	81.73	37.68	90
91	83.13	37.01	82.97	37.38	82.81	37.74	82.64	38.10	91
92	84.05	37.42	83.88	37.79	83.72	38.15	83.55	38.52	92
93	84.96	37.83	84.79	38.20	84.63	38.57	84.46	38.94	93
94	85.87	38.23	85.71	38.61	85.54	38.98	85.37	39.35	94
95	86.79	38.64	86.62	39.02	86.45	39.40	86.27	39.77	95
96	87.70	39.05	87.53	39.43	87.36	39.81	87.18	40.19	96
97	88.61	39.45	88.44	39.84	88.27	40.23	88.09	40.61	97
98	89.53	39.86	89.35	40.25	89.18	40.64	89.00	41.03	98
99	90.44	40.27	90.26	40.66	90.09	41.05	89.91	41.45	99
100	91.35	40.67	91.18	41.07	91.00	41.47	90.81	41.87	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.91	0.42	0.90	0.43	0.90	0.43	0.90	0.43	.
2	1.81	0.85	1.81	0.85	1.81	0.86	1.80	0.87	2
3	2.72	1.27	2.71	1.28	2.71	1.29	2.70	1.30	3
4	3.63	1.69	3.62	1.71	3.61	1.72	3.60	1.74	4
5	4.53	2.11	4.52	2.13	4.51	2.15	4.50	2.17	5
6	5.44	2.54	5.43	2.56	5.42	2.58	5.40	2.61	6
7	6.34	2.96	6.33	2.99	6.32	3.01	6.30	3.04	7
8	7.25	3.38	7.24	3.41	7.22	3.44	7.21	3.48	8
9	8.16	3.80	8.14	3.84	8.12	3.87	8.11	3.91	9
10	9.06	4.23	9.04	4.27	9.03	4.31	9.01	4.34	10
11	9.97	4.65	9.95	4.69	9.93	4.74	9.91	4.78	11
12	10.88	5.07	10.85	5.12	10.83	5.17	10.81	5.21	12
13	11.78	5.49	11.76	5.55	11.73	5.60	11.71	5.65	13
14	12.69	5.92	12.66	5.97	12.64	6.03	12.61	6.08	14
15	13.59	6.34	13.57	6.40	13.54	6.46	13.51	6.52	15
16	14.50	6.76	14.47	6.83	14.44	6.89	14.41	6.95	16
17	15.41	7.18	15.38	7.25	15.34	7.32	15.31	7.39	17
18	16.31	7.61	16.28	7.68	16.23	7.75	16.21	7.82	18
19	17.22	8.03	17.18	8.10	17.15	8.18	17.11	8.25	19
20	18.13	8.45	18.09	8.53	18.05	8.61	18.01	8.69	20
21	19.03	8.87	18.99	8.96	18.95	9.04	18.91	9.12	21
22	19.94	9.30	19.90	9.38	19.86	9.47	19.82	9.56	22
23	20.85	9.72	20.80	9.81	20.76	9.90	20.72	9.99	23
24	21.75	10.14	21.71	10.24	21.66	10.33	21.62	10.43	24
25	22.66	10.57	22.61	10.66	22.56	10.76	22.52	10.86	25
26	23.56	10.99	23.52	11.09	23.47	11.19	23.42	11.30	26
27	24.47	11.41	24.42	11.52	24.37	11.62	24.32	11.73	27
28	25.38	11.83	25.32	11.94	25.27	12.05	25.22	12.16	28
29	26.28	12.26	26:23	12.37	26.17	12.48	26.12	12.60	29
30	27.19	12.68	27.13	12.80	27.08	12.92	27.02	13.03	30
31	28.10	13.10	28.04	13.22	27.98	13.35	27.92	13.47	31
32	29.00	13.52	28.94	13.65	28.88	13.78	28.82	13.90	32
33	29.91	13.95	29.85	14.08	29.79	14.21	29.72	14.34	33
34	30.81	14.37	30.75	14.50	30.69	14.64	30.62	14.77	34
35	31.72	14.79	31.66	14.93	31.59	15.07	31.52	15.21	35
36	32.63	15.21	32.56	15.36	32.49	15.50	32.43	15.64	36
37	33.53	15.64	33.46	15.78	33.40	15.93	33.33	16.07	37
38	34.44	16.06	34.37	16.21	34.30	16.36	34.23	16.51	38
39	35.35	16.48	35.27	16.64	35.20	16.79	35.13	16.94	39
40	36.25	16.90	36.18	17.06	36.10	17.22	36.03	17.38	40
41	37.16	17.33	37.08	17.49	37.01	17.65	36.93	17.81	41
42	38.06	17.75	37.99	17.92	37.91	18.08	37.83	18.25	42
43	38.97	18.17	38.89	18.34	38.81	18.51	38.73	18.68	43
44	39.88	18.60	39.80	18.77	39.71	18.94	39.63	19.12	44
45	40.78	19.02	40.70	19.20	40.62	19.37	40.53	19.55	45
46	41.69	19.44	41.60	19.62	41.52	19.80	41.43	19.98	46
47	42.60	19.86	42.51	20.05	42.42	20.23	42.33	20.42	47
48	43.50	20.29	43.41	20.48	43.32	20.66	43.23	20.85	48
49	44.41	20.71	44.32	20.90	44.23	21.10	44.13	21.29	49
50	45.32	21.13	45.22	21.33	45.13	21.53	45.03	21.72	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg.		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.22	21.55	46.13	21.75	46.03	21.96	45.94	22.16	51
52	47.13	21.98	47.03	22.18	46.93	22.39	46.84	22.59	52
53	48.03	22.40	47.94	22.61	47.84	22.82	47.74	23.03	53
54	48.94	22.82	48.84	23.03	48.74	23.25	48.64	23.46	54
55	49.85	23.24	49.74	23.46	49.64	23.68	49.54	23.89	55
56	50.75	23.67	50.65	23.89	50.54	24.11	50.44	24.33	56
57	51 66	24.09	51.55	24.31	51.45	24.54	51.34	24.76	57
58	52.57	24.51	52.46	24.74	52.35	24.97	52.24	25.20	58
59	53.47	24.93	53.36	25.17	53.25	25.40	53.14	25.63	59
60	54.38	25.36	54.27	25.59	54.16	25.83	54.04	26.07	60
61	55.28	25.78	55.17	26.02	55.06	26.26	54.94	26.50	61
62	56.19	26.20	56.08	26.45	55.96	26.69	55.84	26.94	62
63	57.10	26.62	56.98	26.87	56.86	27.12	56.74	27.37	63
64	58.00	27.05	57.89	27.30	57.77	27.55	57.64	27.80	64
65	58.91	27.47	58.79	27.73	58.67	27.98	58.55	28.24	65
66	59.82	27.89	59.69	28.15	59.57	28.41	59.45	28.67	66
67	60.72	28.32	60.60	28.58	60.47	28.84	60.35	29.11	67
68	61.63	28.74	61.50	29.01	61.38	29.27	61.25	29.54	68
69	62.54	29.16	62.41	29.43	62.28	29.71	62.15	29.98	69
70	63.44	29.58	63.31	29.86	63.18	30.14	63.05	30.41	70
71	64.35	30.01	64.22	30.29	64.08	30.57	63.95	30.85	71
72	65.25	30.43	65.12	30.71	64.99	31.00	64.85	31.28	72
73	66.16	30.85	66.03	31.14	65.89	31.43	65.75	31.71	73
74	67.07	31.27	66.93	31.57	66.79	31.86	66.65	32.15	74
75	67.97	31.70	67.83	31.99	67.69	32.29	67.55	32.58	75
76	68.88	32.12	68.74	32.42	68.60	32.72	68.45	33.02	76
77	69.79	32.54	69.64	32.85	69.50	33.15	69.35	33.45	77
78	70.69	32.96	70.55	33.27	70.40	33.58	70.25	33.89	78
79	71.60	33.39	71.45	33.70	71.30	34.01	71.16	34.32	79
80	72.50	33.81	72.36	34.13	72.21	34.44	72.06	34.76	80
81	73.41	34.23	73.26	34.55	73.11	34.87	72.96	35.19	81
82	74.32	34.65	74.17	34.98	74.01	35.30	73.86	35.62	82
83	75.22	35.08	75.07	35.41	74.91	35.73	74.76	36.06	83
84	76.13	35.50	75.97	35.83	75.82	36.16	75.66	36.49	84
85	77.04	35.92	76.88	36.26	76.72	36.59	76.56	36.93	85
86	77.94	36.35	77.78	36.68	77.62	37.02	77.46	37.36	86
87	78.85	36.77	78.69	37.11	78.52	37.45	78.36	37.80	87
88	79.76	37.19	79.59	37.54	79.43	37.88	79.26	38.23	88
89	80.66	37.61	80.50	37.96	80.33	38.32	80.16	38.67	89
90	81.57	38.04	81.40	38.39	81.23	38.75	81.06	39.10	90
91	82.47	38.46	82.31	38.82	82.14	39.18	81.96	39.53	91
92	83.38	38.88	83.21	39.24	83.04	39.61	82.86	39.97	92
93	84.29	39.30	84.11	39.67	83.94	40.04	83.76	40.40	93
94	85.19	39.73	85.02	40.10	84.84	40.47	84.67	40.84	94
95	86.10	40.15	85.92	40.52	85.75	40.90	85 57	41.27	95
96	87.01	40.57	86.83	40.95	86.65	41.33	86 47	41.71	96
97	87.91	40.99	87.73	41.38	87.55	41.76	87.37	42.14	97
98	88.82	41.42	88.64	41.80	88.45	42.19	88.27	42.58	98
99	89.72	41.84	89.54	42.23	89.36	42.62	89.17	43.01	99
100	90.63	42.26	90.45	42.66	90.26	43.05	90.07	43 44	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.90	0.44	0.90	0.44	0.89	0.45	0.89	0.45	1
2	1.80	0.88	1.79	0.88	1.79	0.89	1.79	0.90	2
3	2.70	1.32	2.69	1.33	2.68	1.34	2.68	1.35	3
4	3.60	1.75	3.59	1.77	3.58	1.78	3.57	1.80	4
5	4.49	2.19	4.48	2.21	4.47	2.23	4.46	2.25	5
6	5.39	2.63	5.38	2.65	5.37	2.68	5.36	2.70	6
7	6.29	3.07	6.28	3.10	6.26	3.12	6.25	3.15	7
8	7.19	3.51	7.17	3.54	7.16	3.57	7.14	3.60	8
9	8.09	3.95	8.07	3.98	8.05	4.02	8.04	4.05	9
10	8.99	4.38	8.97	4.42	8.95	4.46	8.93	4.50	10
11	9.89	4.82	9.87	4.87	9.84	4.91	9.82	4.95	11
12	10.79	5.26	10.76	5.31	10.74	5.35	10.72	5.40	12
13	11.68	5.70	11.66	5.75	11.63	5.80	11.61	5.85	13
14	12.58	6.14	12.56	6.19	12.53	6.25	12.50	6.30	14
15	13.48	6.58	13.45	6.63	13.42	6.69	13.39	6.75	15
16	14.38	7.01	14.35	7.08	14.32	7.14	14.29	7.20	16
17	15.28	7.45	15.25	7.52	15.21	7.59	15.18	7.65	17
18	16.18	7.89	16.14	7.96	16.11	8.03	16.07	8.10	18
19	17.08	8.33	17.04	8.40	17.00	8.48	16.97	8.55	19
20	17.98	8.77	17.94	8.85	17.90	8.92	17.86	9.00	20
21	18.87	9.21	18.83	9.29	18.79	9.37	18.75	9.45	21
22	19.77	9.64	19.73	9.73	19.69	9.82	19.65	9.90	22
23	20.67	10.08	20.63	10.17	20.58	10.26	20.54	10.35	23
24	21.57	10.52	21.52	10.61	21.48	10.71	21.43	10.80	24
25	22.47	10.96	22.42	11.06	22.37	11.15	22.32	11.25	25
26	23.37	11.40	23.32	11.50	23.27	11.60	23.22	11.70	26
27	24.27	11.84	24.22	11.94	24.16	12.05	24.11	12.15	27
28	25.17	12.27	25.11	12.38	25.06	12.49	25.00	12.60	28
29	26.06	12.71	26.01	12.83	25.95	12.94	25.90	13.05	29
30	26.96	13.15	26.91	13.27	26.85	13.39	26.79	13.50	30
31	27.86	13.59	27.80	13.71	27.74	13.83	27.68	13.95	31
32	28.76	14.03	28.70	14.15	28.64	14.28	28.58	14.40	32
33	29.66	14.47	29.60	14.60	29.53	14.72	29.47	14.85	33
34	30.56	14.90	30.49	15.04	30.43	15.17	30.36	15.30	34
35	31.46	15.34	31.39	15.48	31.32	15.62	31.25	15.75	35
36	32.36	15.78	32.29	15.92	32.22	16.06	32.15	16.20	36
37	33.26	16.22	33.18	16.36	33.11	16.51	33.04	16.65	37
38	34.15	16.66	34.08	16.81	34.01	16.96	33.93	17.10	38
39	35.05	17.10	34.98	17.25	34.90	17.40	34.83	17.55	39
40	35.95	17.53	35.87	17.69	35.80	17.85	35.72	18.00	40
41	36.85	17.97	36.77	18.13	36.69	18.29	36.61	18.45	41
42	37.75	18.41	37.67	18.58	37.59	18.74	37.51	18.90	42
43	38.65	18.85	38.57	19.02	38.48	19.19	38.40	19.35	43
44	39.55	19.29	39.46	19.46	39.38	19.63	39.29	19.80	44
45	40.45	19.73	40.36	19.90	40.27	20.08	40.18	20.25	45
46	41.34	20.17	41.26	20.35	41.17	20.53	41.08	20.70	46
47	42.24	20.60	42.15	20.79	42.06	20.97	41.97	21.15	47
48	43.14	21.04	43.05	21.23	42.96	21.42	42.86	21.60	48
49	44.04	21.48	43.95	21.67	43.85	21.86	43.76	22.05	49
50	44.94	21.92	44.84	22.11	44.75	22.31	44.65	22.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.84	22.36	45.74	22.56	45.64	22.76	45.54	22.96	51
52	46.74	22.80	46.64	23.00	46.54	23.20	46.43	23.41	52
53	47.64	23.23	47.53	23.44	47.43	23.65	47.33	23.86	53
54	48.53	23.67	48.43	23.88	48.33	24.09	48.22	24.31	54
55	49.43	24.11	49.33	24.33	49.22	24.54	49.11	24.76	55
56	50.33	24.55	50.22	24.77	50.12	24.99	50.01	25.21	56
57	51.23	24.99	51.12	25.21	51.01	25.43	50.90	25.66	57
58	52.13	25.43	52.02	25.65	51.91	25.88	51.79	26.11	58
59	53.03	25.86	52.92	26.09	52.80	26.33	52.69	26.56	59
60	53.93	26.30	53.81	26.54	53.70	26.77	53.58	27.01	60
61	54.83	26.74	54.71	26.98	54.59	27.22	54.47	27.46	61
62	55.73	27.18	55.61	27.42	55.49	27.66	55.36	27.91	62
63	56.62	27.62	56.50	27.86	56.38	28.11	56.26	28.36	63
64	57.52	28.06	57.40	28.31	57.28	28.56	57.15	28.81	64
65	58.42	28.49	58.30	28.75	58.17	29.00	58.04	29.26	65
66	59.32	28.93	59.19	29.19	59.07	29.45	58.94	29.71	66
67	60.22	29.37	60.09	29.63	59.96	29.90	59.83	30.16	67
68	61.12	29.81	60.99	30.08	60.86	30.34	60.72	30.61	68
69	62.02	30.25	61.88	30.52	61.75	30.79	61.62	31.06	69
70	62.92	30.69	62.78	30.96	62.65	31.23	62.51	31.51	70
71	63.81	31.12	63.68	31.40	63.54	31.68	63.40	31.96	71
72	64.71	31.56	64.57	31.84	64.44	32.13	64.29	32.41	72
73	65.61	32.00	65.47	32.29	65.33	32.57	65.19	32.86	73
74	66.51	32.44	66.37	32.73	66.23	33.02	66.08	33.31	74
75	67.41	32.88	67.27	33.17	67.12	33.46	66.97	33.76	75
76	68.31	33.32	68.16	33.61	68.01	33.91	67.87	34.21	76
77	69.21	33.75	69.06	34.06	68.91	34.36	68.76	34.66	77
78	70.11	34.19	69.96	34.50	69.80	34.80	69.65	35.11	78
79	71.00	34.63	70.85	34.94	70.70	35.25	70.55	35.56	79
80	71.90	35.07	71.75	35.38	71.59	35.70	71.44	36.01	80
81	72.80	35.51	72.65	35.83	72.49	36.14	72.33	36.46	81
82	73.70	35.95	73.54	36.27	73.38	36.59	73.22	36.91	82
83	74.60	36.38	74.44	36.71	74.28	37.03	74.12	37.36	83
84	75.50	36.82	75.34	37.15	75.17	37.48	75.01	37.81	84
85	76.40	37.26	76.23	37.59	76.07	37.93	75.90	38.26	85
86	77.30	37.70	77.13	38.04	76.96	38.37	76.80	38.71	86
87	78.20	38.14	78.03	38.48	77.86	38.82	77.69	39.16	87
88	79.09	38.58	78.92	38.92	78.75	39.27	78.58	39.61	88
89	79.99	39.01	79.82	39.36	79.65	39.71	79.48	40.06	89
90	80.89	39.45	80.72	39.81	80.54	40.16	80.37	40.51	90
91	81.79	39.89	81.62	40.25	81.44	40.60	81.26	40.96	91
92	82.69	40.33	82.51	40.69	82.33	41.05	82.15	41.41	92
93	83.59	40.77	83.41	41.13	83.23	41.50	83.05	41.86	93
94	84.49	41.21	84.31	41.58	84.12	41.94	83.94	42.31	94
95	85.39	41.65	85.20	42.02	85.02	42.39	84.83	42.76	95
96	86.28	42.08	86.10	42.46	85.91	42.83	85.73	43.21	96
97	87.18	42.52	87.00	42.90	86.81	43.28	86.62	43.66	97
98	88.08	42.96	87.89	43.34	87.70	43.73	87.51	44.11	98
99	88.98	43.40	88.79	43.79	88.60	44.17	88.40	44.56	99
100	89.88	43.84	89.69	44.23	89.49	44.62	89.30	45.01	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat	Dep.	
1	0.89	0.45	0.89	0.46	0.89	0.46	0.88	0.47	1
2	1.78	0.91	1.78	0.92	1.77	0.92	1.77	0.93	2
3	2.67	1.36	2.67	1.37	2.66	1.39	2.65	1.40	3
4	3.56	1.82	3.56	1.83	3.55	1.85	3.54	1.86	4
5	4.45	2.27	4.45	2.29	4.44	2.31	4.42	2.33	5
6	5.35	2.72	5.33	2.75	5.32	2.77	5.31	2.79	6
7	6.24	3.18	6.22	3.21	6.21	3.23	6.19	3.26	7
8	7.13	3.63	7.11	3.66	7.10	3.69	7.08	3.72	8
9	8.02	4.09	8.00	4.12	7.98	4.16	7.96	4.19	9
10	8.91	4.54	8.89	4.58	8.87	4.62	8.85	4.66	10
11	9.80	4.99	9.78	5.04	9.76	5.08	9.73	5.12	11
12	10.69	5.45	10.67	5.49	10.64	5.54	10.62	5.59	12
13	11.58	5.90	11.56	5.95	11.53	6.00	11.50	6.05	13
14	12.47	6.36	12.45	6.41	12.42	6.46	12.39	6.52	14
15	13.37	6.81	13.34	6.87	13.31	6.93	13.27	6.98	15
16	14.26	7.26	14.22	7.33	14.19	7.39	14.16	7.45	16
17	15.15	7.72	15.11	7.78	15.08	7.85	15.04	7.92	17
18	16.04	8.17	16.00	8.24	15.97	8.31	15.93	8.38	18
19	16.93	8.63	16.89	8.70	16.85	8.77	16.81	8.85	19
20	17.82	9.08	17.78	9.16	17.74	9.23	17.70	9.31	20
21	18.71	9.53	18.67	9.62	18.63	9.70	18.58	9.78	21
22	19.60	9.99	19.56	10.07	19.51	10.16	19.47	10.24	22
23	20.49	10.44	20.45	10.53	20.40	10.62	20.35	10.71	23
24	21.38	10.90	21.34	10.99	21.29	11.08	21.24	11.17	24
25	22.28	11.35	22.23	11.45	22.18	11.54	22.12	11.64	25
26	23.17	11.80	23.11	11.90	23.06	12.01	23.01	12.11	26
27	24.06	12.26	24.00	12.36	23.95	12.47	23.89	12.57	27
28	24.95	12.71	24.89	12.82	24.84	12.93	24.78	13.04	28
29	25.84	13.17	25.78	13.28	25.72	13.39	25.66	13.50	29
30	26.73	13.62	26.67	13.74	26.61	13.85	26.55	13.97	30
31	27.62	14.07	27.56	14.19	27.50	14.31	27.43	14.43	31
32	28.51	14.53	28.45	14.65	28.38	14.78	28.32	14.90	32
33	29.40	14.98	29.34	15.11	29.27	15.24	29.20	15.37	33
34	30.29	15.44	30.23	15.57	30.16	15.70	30.09	15.83	34
35	31.19	15.89	31.12	16.03	31.05	16.16	30.97	16.30	35
36	32.08	16.34	32.00	16.48	31.93	16.62	31.86	16.76	36
37	32.97	16.80	32.89	16.94	32.82	17.08	32.74	17.23	37
38	33.86	17.25	33.78	17.40	33.71	17.55	33.63	17.69	38
39	34.75	17.71	34.67	17.86	34.59	18.01	34.51	18.16	39
40	35.64	18.16	35.56	18.31	35.48	18.47	35.40	18.62	40
41	36.53	18.61	36.45	18.77	36.37	18.93	36.28	19.09	41
42	37.42	19.07	37.34	19.23	37.25	19.39	37.17	19.56	42
43	38.31	19.52	38.23	19.69	38.14	19.86	38.05	20.02	43
44	39.20	19.98	39.12	20.15	39.03	20.32	38.94	20.49	44
45	40.10	20.43	40.01	20.60	39.92	20.78	39.82	20.95	45
46	40.99	20.88	40.89	21.06	40.80	21.24	40.71	21.42	46
47	41.88	21.34	41.78	21.52	41.69	21.70	41.59	21.88	47
48	42.77	21.79	42.67	21.98	42.58	22.16	42.48	22.35	48
49	43.66	22.25	43.56	22.44	43.46	22.63	43.36	22.82	49
50	44.55	22.70	44.45	22.89	44.35	23.09	44.25	23.28	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Distance.
	63 Deg.		62¾ Deg.		62½ Deg		62¼ Deg.		

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.44	23.15	45.34	23.35	45.24	23.55	45.13	23.75	51
52	46.33	23.61	46.23	23.81	46.12	24.01	46.02	24.21	52
53	47.22	24.06	47.12	24.27	47.01	24.47	46.90	24.68	53
54	48.11	24.52	48.01	24.73	47.90	24.93	47.79	25.14	54
55	49.01	24.97	48.90	25.18	48.79	25.40	48.67	25.61	55
56	49.90	25.42	49.78	25.64	49.67	25.86	49.56	26.07	56
57	50.79	25.88	50.67	26.10	50.56	26.32	50.44	26.54	57
58	51.68	26.33	51.56	26.56	51.45	26.78	51.33	27.01	58
59	52.57	26.79	52.45	27.01	52.33	27.24	52.21	27.47	59
60	53.46	27.24	53.34	27.47	53.22	27.70	53.10	27.94	60
61	54.35	27.69	54.23	27.93	54.11	28.17	53.98	28.40	61
62	55.24	28.15	55.12	28.39	54.99	28.63	54.87	28.87	62
63	56.13	28.60	56.01	28.85	55.88	29.09	55.75	29.33	63
64	57.02	29.06	56.90	29.30	56.77	29.55	56.64	29.80	64
65	57.92	29.51	57.79	29.76	57.66	30.01	57.52	30.26	65
66	58.81	29.96	58.68	30.22	58.54	30.48	58.41	30.73	66
67	59.70	30.42	59.56	30.68	59.43	30.94	59.29	31.20	67
68	60.59	30.87	60.45	31.14	60.32	31.40	60.18	31.66	68
69	61.48	31.33	61.34	31.59	61.20	31.86	61.06	32.13	69
70	62.37	31.78	62.23	32.05	62.09	32.32	61.95	32.59	70
71	63.26	32.23	63.12	32.51	62.98	32.78	62.83	33.06	71
72	64.15	32.69	64.01	32.97	63.86	33.25	63.72	33.52	72
73	65.04	33.14	64.90	33.42	64.75	33.71	64.60	33.99	73
74	65.93	33.60	65.79	33.88	65.64	34.17	65.49	34.46	74
75	66.83	34.05	66.68	34.34	66.53	34.63	66.37	34.92	75
76	67.72	34.50	67.57	34.80	67.41	35.09	67.26	35.39	76
77	68.61	34.96	68.45	35.26	68.30	35.55	68.14	35.85	77
78	69.50	35.41	69.34	35.71	69.19	36.02	69.03	36.32	78
79	70.39	35.87	70.23	36.17	70.07	36.48	69.91	36.78	79
80	71.28	36.32	71.12	36.63	70.96	36.94	70.80	37.25	80
81	72.17	36.77	72.01	37.09	71.85	37.40	71.68	37.71	81
82	73.06	37.23	72.90	37.55	72.73	37.86	72.57	38.18	82
83	73.95	37.68	73.79	38.00	73.62	38.33	73.45	38.65	83
84	74.84	38.14	74.68	38.46	74.51	38.79	74.34	39.11	84
85	75.74	38.59	75.57	38.92	75.40	39.25	75.22	39.58	85
86	76.63	39.04	76.46	39.38	76.28	39.71	76.11	40.04	86
87	77.52	39.50	77.34	39.83	77.17	40.17	76.99	40.51	87
88	78.41	39.95	78.23	40.29	78.06	40.63	77.88	40.97	88
89	79.30	40.41	79.12	40.75	78.94	41.10	78.76	41.44	89
90	80.19	40.86	80.01	41.21	79.83	41.56	79.65	41.91	90
91	81.08	41.31	80.90	41.67	80.72	42.02	80.53	42.37	91
92	81.97	41.77	81.79	42.12	81.60	42.48	81.42	42.84	92
93	82.86	42.22	82.68	42.58	82.49	42.94	82.30	43.30	93
94	83.75	42.68	83.57	43.04	83.38	43.40	83.19	43.77	94
95	84.65	43.13	84.46	43.50	84.27	43.87	84.07	44.23	95
96	85.54	43.58	85.35	43.96	85.15	44.33	84.96	44.70	96
97	86.43	44.04	86.23	44.41	86.04	44.79	85.84	45.16	97
98	87.32	44.49	87.12	44.87	86.93	45.25	86.73	45.63	98
99	88.21	44.95	88.01	45.33	87.81	45.71	87.61	46.10	99
100	89.10	45.40	88.90	45.79	88.70	46.17	88.50	46.56	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	63 Deg.		62¾ Deg.		62½ Deg.		62¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.88	0.47	0.88	0.47	0.88	0.48	0.88	0.48	1
2	1.77	0.94	1.76	0.95	1.76	0.95	1.75	0.96	2
3	2.65	1.41	2.64	1.42	2.64	1.43	2.63	1.44	3
4	3.53	1.88	3.52	1.89	3.52	1.91	3.51	1.92	4
5	4.41	2.35	4.40	2.37	4.39	2.39	4.38	2.40	5
6	5.30	2.82	5.29	2.84	5.27	2.86	5.26	2.89	6
7	6.18	3.29	6.17	3.31	6.15	3.34	6.14	3.37	7
8	7.06	3.76	7.05	3.79	7.03	3.82	7.01	3.85	8
9	7.95	4.23	7.93	4.26	7.91	4.29	7.89	4.33	9
10	8.83	4.69	8.81	4.73	8.79	4.77	8.77	4.81	10
11	9.71	5.16	9.69	5.21	9.67	5.25	9.64	5.29	11
12	10.60	5.63	10.57	5.68	10.55	5.73	10.52	5.77	12
13	11.48	6.10	11.45	6.15	11.42	6.20	11.40	6.25	13
14	12.36	6.57	12.33	6.63	12.30	6.68	12.27	6.73	14
15	13.24	7.04	13.21	7.10	13.18	7.16	13.15	7.21	15
16	14.13	7.51	14.09	7.57	14.06	7.63	14.03	7.70	16
17	15.01	7.98	14.98	8.05	14.94	8.11	14.90	8.18	17
18	15.89	8.45	15.86	8.52	15.82	8.59	15.78	8.66	18
19	16.78	8.92	16.74	8.99	16.70	9.07	16.66	9.14	19
20	17.66	9.39	17.62	9.47	17.58	9.54	17.53	9.62	20
21	18.54	9.86	18.50	9.94	18.46	10.02	18.41	10.10	21
22	19.42	10.33	19.38	10.41	19.33	10.50	19.29	10.58	22
23	20.31	10.80	20.26	10.89	20.21	10.97	20.16	11.06	23
24	21.19	11.27	21.14	11.36	21.09	11.45	21.04	11.54	24
25	22.07	11.74	22.02	11.83	21.97	11.93	21.92	12.02	25
26	22.96	12.21	22.90	12.31	22.85	12.41	22.79	12.51	26
27	23.84	12.68	23.78	12.78	23.73	12.88	23.67	12.99	27
28	24.72	13.15	24.66	13.25	24.61	13.36	24.55	13.47	28
29	25.61	13.61	25.55	13.73	25.49	13.84	25.43	13.95	29
30	26.49	14.08	26.43	14.20	26.36	14.31	26.30	14.43	30
31	27.37	14.55	27.31	14.67	27.24	14.79	27.18	14.91	31
32	28.25	15.02	28.19	15.15	28.12	15.27	28.06	15.39	32
33	29.14	15.49	29.07	15.62	29.00	15.75	28.93	15.87	33
34	30.02	15.96	29.95	16.09	29.88	16.22	29.81	16.35	34
35	30.90	16.43	30.83	16.57	30.76	16.70	30.69	16.83	35
36	31.79	16.90	31.71	17.04	31.64	17.18	31.56	17.32	36
37	32.67	17.37	32.59	17.51	32.52	17.65	32.44	17.80	37
38	33.55	17.84	33.47	17.99	33.39	18.13	33.32	18.28	38
39	34.43	18.31	34.35	18.46	34.27	18.61	34.19	18.76	39
40	35.32	18.78	35.24	18.93	35.15	19.09	35.07	19.24	40
41	36.20	19.25	36.12	19.41	36.03	19.56	35.95	19.72	41
42	37.08	19.72	37.00	19.88	36.91	20.04	36.82	20.20	42
43	37.97	20.19	37.88	20.35	37.79	20.52	37.70	20.68	43
44	38.85	20.66	38.76	20.83	38.67	20.99	38.58	21.16	44
45	39.73	21.13	39.64	21.30	39.55	21.47	39.45	21.64	45
46	40.62	21.60	40.52	21.77	40.43	21.95	40.33	22.13	46
47	41.50	22.07	41.40	22.25	41.30	22.43	41.21	22.61	47
48	42.38	22.53	42.28	22.72	42.18	22.90	42.08	23.09	48
49	43.26	23.00	43.16	23.19	43.06	23.38	42.96	23.57	49
50	44.15	23.47	44.04	23.67	43.94	23.86	43.84	24.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.03	23.94	44.93	24.14	44.82	24.34	44.71	24.53	51
52	45.91	24.41	45.81	24.61	45.70	24.81	45.59	25.01	52
53	46.80	24.88	46.69	25.09	46.58	25.29	46.47	25.49	53
54	47.68	25.35	47.57	25.56	47.46	25.77	47.34	25.97	54
55	48.56	25.82	48.45	26.03	48.33	26.24	48.22	26.45	55
56	49.45	26.29	49.33	26.51	49.21	26.72	49.10	26.94	56
57	50.33	26.76	50.21	26.98	50.09	27.20	49.97	27.42	57
58	51.21	27.23	51.09	27.45	50.97	27.68	50.85	27.90	58
59	52.09	27.70	51.97	27.93	51.85	28.15	51.73	28.38	59
60	52.98	28.17	52.85	28.40	52.73	28.63	52.60	28.86	60
61	53.86	28.64	53.73	28.87	53.61	29.11	53.48	29.34	61
62	54.74	29.11	54.62	29.35	54.49	29.58	54.36	29.82	62
63	55.63	29.58	55.50	29.82	55.37	30.06	55.23	30.30	63
64	56.51	30.05	56.38	30.29	56.24	30.54	56.11	30.78	64
65	57.39	30.52	57.26	30.77	57.12	31.02	56.99	31.26	65
66	58.27	30.99	58.14	31.24	58.00	31.49	57.86	31.75	66
67	59.16	31.45	59.02	31.71	58.88	31.97	58.74	32.23	67
68	60.04	31.92	59.90	32.19	59.76	32.45	59.62	32.71	68
69	60.92	32.39	60.78	32.66	60.64	32.92	60.49	33.19	69
70	61.81	32.86	61.66	33.13	61.52	33.40	61.37	33.67	70
71	62.69	33.33	62.54	33.61	62.40	33.88	62.25	34.15	71
72	63.57	33.80	63.42	34.08	63.27	34.36	63.12	34.63	72
73	64.46	34.27	64.30	34.55	64.15	34.83	64.00	35.11	73
74	65.34	34.74	65.19	35.03	65.03	35.31	64.88	35.59	74
75	66.22	35.21	66.07	35.50	65.91	35.79	65.75	36.07	75
76	67.10	35.68	66.95	35.97	66.79	36.26	66.63	36.56	76
77	67.99	36.15	67.83	36.45	67.67	36.74	67.51	37.04	77
78	68.87	36.62	68.71	36.92	68.55	37.22	68.38	37.52	78
79	69.75	37.09	69.59	37.39	69.43	37.70	69.26	38.00	79
80	70.64	37.56	70.47	37.87	70.31	38.17	70.14	38.48	80
81	71.52	38.03	71.35	38.34	71.18	38.65	71.01	38.96	81
82	72.40	38.50	72.23	38.81	72.06	39.13	71.89	39.44	82
83	73.28	38.97	73.11	39.29	72.94	39.60	72.77	39.92	83
84	74.17	39.44	73.99	39.76	73.82	40.08	73.64	40.40	84
85	75.05	39.91	74.88	40.23	74.70	40.56	74.52	40.88	85
86	75.93	40.37	75.76	40.71	75 58	41.04	75.40	41.36	86
87	76.82	40.84	76.64	41.18	76.46	41.51	76.28	41.85	87
88	77.70	41.31	77.52	41.65	77.34	41.99	77.15	42.33	88
89	78.58	41.78	78.40	42.13	78.21	42.47	78.03	42.81	89
90	79.47	42.25	79.28	42.60	79.09	42.94	78.91	43.29	90
91	80.35	42.72	80.16	43.07	79.97	43.42	79.78	43.77	91
92	81.23	43.19	81.04	43.55	80.85	43.90	80.66	44.25	92
93	82.11	43.66	81.92	44.02	81.73	44.38	81.54	44.73	93
94	83.00	44.13	82.80	44.49	82.61	44.85	82.41	45.21	94
95	83.88	44.60	83.68	44.97	83.49	45.33	83.29	45.69	95
96	84.76	45.07	84.57	45.44	84.37	45.81	84.17	46.17	96
97	85.65	45.54	85.45	45.91	85.25	46.28	85.04	46.66	97
98	86.53	46.01	86 33	46.39	86.12	46.76	85.92	47.14	98
99	87.41	46.48	87.21	46.86	87.00	47.24	86.80	47.62	99
100	88.29	46.95	88.09	47.33	87.88	47.72	87.67	48.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	29 Deg.		29¼ Deg.		29½ Deg.		29¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.87	0.48	0.87	0.49	0.87	0.49	0.87	0.50	1
2	1.75	0.97	1.74	0.98	1.74	0.98	1.74	0.99	2
3	2.62	1.45	2.62	1.47	2.61	1.48	2.60	1.49	3
4	3.50	1.94	3.49	1.95	3.48	1.97	3.47	1.98	4
5	4.37	2.42	4.36	2.44	4.35	2.46	4.34	2.48	5
6	5.25	2.91	5.23	2.93	5.22	2.95	5.21	2.98	6
7	6.12	3.39	6.11	3.42	6.09	3.45	6.08	3.47	7
8	7.00	3.88	6.98	3.91	6.96	3.94	6.95	3.97	8
9	7.87	4.36	7.85	4.40	7.83	4.43	7.81	4.47	9
10	8.75	4.85	8.72	4.89	8.70	4.92	8.68	4.96	10
11	9.62	5.33	9.60	5.37	9.57	5.42	9.55	5.46	11
12	10.50	5.82	10.47	5.86	10.44	5.91	10.42	5.95	12
13	11.37	6.30	11.34	6.35	11.31	6.40	11.29	6.45	13
14	12.24	6.79	12.21	6.84	12.18	6.89	12.15	6.95	14
15	13.12	7.27	13.09	7.33	13.06	7.39	13.02	7.44	15
16	13.99	7.76	13.96	7.82	13.93	7.88	13.89	7.94	16
17	14.87	8.24	14.83	8.31	14.80	8.37	14.76	8.44	17
18	15.74	8.73	15.70	8.80	15.67	8.86	15.63	8.93	18
19	16.62	9.21	16.58	9.28	16.54	9.36	16.50	9.43	19
20	17.49	9.70	17.45	9.77	17.41	9.85	17.36	9.92	20
21	18.37	10.18	18.32	10.26	18.28	10.34	18.23	10.42	21
22	19.24	10.67	19.19	10.75	19.15	10.83	19.10	10.92	22
23	20.12	11.15	20.07	11.24	20.02	11.33	19.97	11.41	23
24	20.99	11.64	20.94	11.73	20.89	11.82	20.84	11.91	24
25	21.87	12.12	21.81	12.22	21.76	12.31	21.70	12.41	25
26	22.74	12.60	22.68	12.70	22.63	12.80	22.57	12.90	26
27	23.61	13.09	23.56	13.19	23.50	13.30	23.44	13.40	27
28	24.49	13.57	24.43	13.68	24.37	13.79	24.31	13.89	28
29	25.36	14.06	25.30	14.17	25.24	14.28	25.18	14.39	29
30	26.24	14.54	26.17	14.66	26.11	14.77	26.05	14.89	30
31	27.11	15.03	27.05	15.15	26.98	15.27	26.91	15.38	31
32	27.99	15.51	27.92	15.64	27.85	15.76	27.78	15.88	32
33	28.86	16.00	28.79	16.12	28.72	16.25	28.65	16.38	33
34	29.74	16.48	29.66	16.61	29.59	16.74	29.52	16.87	34
35	30.61	16.97	30.54	17.10	30.46	17.23	30.39	17.37	35
36	31.49	17.45	31.41	17.59	31.33	17.73	31.26	17.86	36
37	32.36	17.94	32.28	18.08	32.20	18.22	32.12	18.36	37
38	33.24	18.42	33.15	18.57	33.07	18.71	32.99	18.86	38
39	34.11	18.91	34.03	19.06	33.94	19.20	33.86	19.35	39
40	34.98	19.39	34.90	19.54	34.81	19.70	34.73	19.85	40
41	35.86	19.88	35.77	20.03	35.68	20.19	35.60	20.34	41
42	36.73	20.36	36.64	20.52	36.55	20.68	36.46	20.84	42
43	37.61	20.85	37.52	21.01	37.43	21.17	37.33	21.34	43
44	38.48	21.33	38.39	21.50	38.30	21.67	38.20	21.83	44
45	39.36	21.82	39.26	21.99	39.17	22.16	39.07	22.33	45
46	40.23	22.30	40.13	22.48	40.04	22.65	39.94	22.83	46
47	41.11	22.79	41.01	22.97	40.91	23.14	40.81	23.32	47
48	41.98	23.27	41.88	23.45	41.78	23.68	41.67	23.82	48
49	42.86	23.76	42.75	23.94	42.65	24.13	42.54	24.31	49
50	43.73	24.24	43.62	24.43	43.52	24.62	43.41	24.81	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		

Distance.	29 Deg.		29¼ Deg.		29½ Deg.		29¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.61	24.73	44.50	24.92	44.39	25.11	44.28	25.31	51
52	45.48	25.21	45.37	25.41	45.26	25.61	45.15	25.80	52
53	46.35	25.69	46.24	25.90	46.13	26.10	46.01	26.30	53
54	47.23	26.18	47.11	26.39	47.00	26.59	46.88	26.80	54
55	48.10	26.66	47.99	26.87	47.87	27.08	47.75	27.29	55
56	48.98	27.15	48.86	27.36	48.74	27.58	48.62	27.79	56
57	49.85	27.63	49.73	27.85	49.61	28.07	49.49	28.28	57
58	50.73	28.12	50.60	28.34	50.48	28.56	50.36	28.78	58
59	51.60	28.60	51.48	28.83	51.35	29.05	51.22	29.28	59
60	52.48	29.09	52.35	29.32	52.22	29.55	52.09	29.77	60
61	53.35	29.57	53.22	29.81	53.09	30.04	52.96	30.27	61
62	54.23	30.06	54.09	30.29	53.96	30.53	53.83	30.77	62
63	55.10	30.54	54.97	30.78	54.83	31.02	54.70	31.26	63
64	55.98	31.03	55.84	31.27	55.70	31.52	55.56	31.76	64
65	56.85	31.51	56.71	31.76	56.57	32.01	56.43	32.25	65
66	57.72	32.00	57.58	32.25	57.44	32.50	57.30	32.75	66
67	58.60	32.48	58.46	32.74	58.31	32.99	58.17	33.25	67
68	59.47	32.97	59.33	33.23	59.18	33.48	59.04	33.74	68
69	60.35	33.45	60.20	33.71	60.05	33.98	59.91	34.24	69
70	61.22	33.94	61.07	34.20	60.92	34.47	60.77	34.74	70
71	62.10	34.42	61.95	34.69	61.80	34.96	61.64	35.23	71
72	62.97	34.91	62.82	35.18	62.67	35.45	62.51	35.73	72
73	63.85	35.39	63.69	35.67	63.54	35.95	63.38	36.22	73
74	64.72	35.88	64.56	36.16	64.41	36.44	64.25	36.72	74
75	65.60	36.36	65.44	36.65	65.28	36.93	65.11	37.22	75
76	66.47	36.85	66.31	37.14	66.15	37.42	65.98	37.71	76
77	67.35	37.33	67.18	37.62	67.02	37.92	66.85	38.21	77
78	68.22	37.82	68.05	38.11	67.89	38.41	67.72	38.70	78
79	69.09	38.30	68.93	38.60	68.76	38.90	68.59	39.20	79
80	69.97	38.78	69.80	39.09	69.63	39.39	69.46	39.70	80
81	70.84	39.27	70.67	39.58	70.50	39.89	70.32	40.19	81
82	71.72	39.75	71.54	40.07	71.37	40.38	71.19	40.69	82
83	72.59	40.24	72.42	40.56	72.24	40.87	72.06	41.19	83
84	73.47	40.72	73.29	41.04	73.11	41.36	72.93	41.68	84
85	74.34	41.21	74.16	41.53	73.98	41.86	73.80	42.18	85
86	75.22	41.69	75.03	42.02	74.85	42.35	74.67	42.67	86
87	76.09	42.18	75.91	42.51	75.72	42.84	75.53	43.17	87
88	76.97	42.66	76.78	43.00	76.59	43.33	76.40	43.67	88
89	77.84	43.15	77.65	43.49	77.46	43.83	77.27	44.16	89
90	78.72	43.63	78.52	43.98	78.33	44.32	78.14	44.66	90
91	79.59	44.12	79.40	44.46	79.20	44.81	79.01	45.16	91
92	80.46	44.60	80.27	44.95	80.07	45.30	79.87	45.65	92
93	81.34	45.09	81.14	45.44	80.94	45.80	80.74	46.15	93
94	82.21	45.57	82.01	45.93	81.81	46.29	81.61	46.64	94
95	83.09	46.06	82.89	46.42	82.68	46.78	82.48	47.14	95
96	83.96	46.54	83.76	46.91	83.55	47.27	83.35	47.64	96
97	84.84	47.03	84.63	47.40	84.42	47.77	84.22	48.13	97
98	85.71	47.51	85.50	47.88	85.29	48.26	85.08	48.63	98
99	86.59	48.00	86.38	48.37	86.17	48.75	85.95	49.13	99
100	87.46	48.48	87.25	48.86	87.04	49.24	86.82	49.62	100
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		Distance.

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.87	0.50	0.86	0.50	0.86	0.51	0.86	0.51	1
2	1.73	1.00	1.73	1.01	1.72	1.02	1.72	1.02	2
3	2.60	1.50	2.59	1.51	2.58	1.52	2.58	1.53	3
4	3.46	2.00	3.46	2.02	3.45	2.03	3.44	2.05	4
5	4.33	2.50	4.32	2.52	4.31	2.54	4.30	2.56	5
6	5.20	3.00	5.18	3.02	5.17	3.05	5.16	3.07	6
7	6.06	3.50	6.05	3.53	6.03	3.55	6.02	3.58	7
8	6.93	4.00	6.91	4.03	6.89	4.06	6.88	4.09	8
9	7.79	4.50	7.77	4.53	7.75	4.57	7.73	4.60	9
10	8.66	5.00	8.64	5.04	8.62	5.08	8.59	5.11	10
11	9.53	5.50	9.50	5.54	9.48	5.58	9.45	5.62	11
12	10.39	6.00	10.37	6.05	10.34	6.09	10.31	6.14	12
13	11.26	6.50	11.23	6.55	11.20	6.60	11.17	6.65	13
14	12.12	7.00	12.09	7.05	12.06	7.11	12.03	7.16	14
15	12.99	7.50	12.96	7.56	12.92	7.61	12.89	7.67	15
16	13.86	8.00	13.82	8.06	13.79	8.12	13.75	8.18	16
17	14.72	8.50	14.69	8.56	14.65	8.63	14.61	8.69	17
18	15.59	9.00	15.55	9.07	15.51	9.14	15.47	9.20	18
19	16.45	9.50	16.41	9.57	16.37	9.64	16.33	9.71	19
20	17.32	10.00	17.28	10.08	17.23	10.15	17.19	10.23	20
21	18.19	10.50	18.14	10.58	18.09	10.66	18.05	10.74	21
22	19.05	11.00	19.00	11.08	18.96	11.17	18.91	11.25	22
23	19.92	11.50	19.87	11.59	19.82	11.67	19.77	11.76	23
24	20.78	12.00	20.73	12.09	20.68	12.18	20.63	12.27	24
25	21.65	12.50	21.60	12.59	21.54	12.69	21.49	12.78	25
26	22.52	13.00	22.46	13.10	22.40	13.20	22.34	13.29	26
27	23.38	13.50	23.32	13.60	23.26	13.70	23.20	13.80	27
28	24.25	14.00	24.19	14.11	24.13	14.21	24.06	14.32	28
29	25.11	14.50	25.05	14.61	24.99	14.72	24.92	14.83	29
30	25.98	15.00	25.92	15.11	25.85	15.23	25.78	15.34	30
31	26.85	15.50	26.78	15.62	26.71	15.73	26.64	15.85	31
32	27.71	16.00	27.64	16.12	27.57	16.24	27.50	16.36	32
33	28.58	16.50	28.51	16.62	28.43	16.75	28.36	16.87	33
34	29.44	17.00	29.37	17.13	29.30	17.26	29.22	17.38	34
35	30.31	17.50	30.23	17.63	30.16	17.76	30.08	17.90	35
36	31.18	18.00	31.10	18.14	31.02	18.27	30.94	18.41	36
37	32.04	18.50	31.96	18.64	31.88	18.78	31.80	18.92	37
38	32.91	19.00	32.83	19.14	32.74	19.29	32.66	19.43	38
39	33.77	19.50	33.69	19.65	33.60	19.79	33.52	19.94	39
40	34.64	20.00	34.55	20.15	34.47	20.30	34.38	20.45	40
41	35.51	20.50	35.42	20.65	35.33	20.81	35.24	20.96	41
42	36.37	21.00	36.28	21.16	36.19	21.32	36.10	21.47	42
43	37.24	21.50	37.14	21.66	37.05	21.82	36.95	21.99	43
44	38.11	22.00	38.01	22.17	37.91	22.33	37.81	22.50	44
45	38.97	22.50	38.87	22.67	33.77	22.84	38.67	23.01	45
46	39.34	23.00	39.74	23.17	39.63	23.35	39.53	23.52	46
47	40.70	23.59	40.60	23.68	40.50	23.85	40.39	24.03	47
48	41.57	24.00	41.46	24.18	41.36	24.36	41.25	24.54	48
49	42.44	24.50	42.33	24.68	42.22	24.87	42.11	25.05	49
50	43.30	25.00	43.19	25.19	43.08	25.38	42.97	25.56	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.17	25.50	44.06	25.69	43.94	25.88	43.83	26.08	51
52	45.03	26.00	44.92	26.20	44.80	26.39	44.69	26.59	52
53	45.90	26.50	45.78	26.70	45.67	26.90	45.55	27.10	53
54	46.77	27.00	46.65	27.20	46.53	27.41	46.41	27.61	54
55	47.63	27.50	47.51	27.71	47.39	27.91	47.27	28.12	55
56	48.50	28.00	48.37	28.21	48.25	28.42	48.13	28.63	56
57	49.36	28.50	49.24	28.72	49.11	28.93	48.99	29.14	57
58	50.23	29.00	50.10	29.22	49.97	29.44	49.85	29.65	58
59	51.10	29.50	50.97	29.72	50.84	29.94	50.70	30.17	59
60	51.96	30.00	51.83	30.23	51.70	30.45	51.56	30.68	60
61	52.83	30.50	52.69	30.73	52.56	30.96	52.42	31.19	61
62	53.69	31.00	53.56	31.23	53.42	31.47	53.28	31.70	62
63	54.56	31.50	54.42	31.74	54.28	31.97	54.14	32.21	63
64	55.43	32.00	55.29	32.24	55.14	32.48	55.00	32.72	64
65	56.29	32.50	56.15	32.75	56.01	32.99	55.86	33.23	65
66	57.16	33.00	57.01	33.25	56.87	33.50	56.72	33.75	66
67	58.02	33.50	57.88	33.75	57.73	34.01	57.58	34.26	67
68	58.89	34.00	58.74	34.26	58.59	34.51	58.44	34.77	68
69	59.76	34.50	59.60	34.76	59.45	35.02	59.30	35.28	69
70	60.62	35.00	60.47	35.26	60.31	35.53	60.16	35.79	70
71	61.49	35.50	61.33	35.77	61.18	36.04	61.02	36.30	71
72	62.35	36.00	62.20	36.27	62.04	36.54	61.88	36.81	72
73	63.22	36.50	63.06	36.78	62.90	37.05	62.74	37.32	73
74	64.09	37.00	63.92	37.28	63.76	37.56	63.60	37.84	74
75	64.95	37.50	64.79	37.78	64.62	38.07	64.46	38.35	75
76	65.82	38.00	65.65	38.29	65.48	38.57	65.31	38.86	76
77	66.68	38.50	66.52	38.79	66.35	39.08	66.17	39.37	77
78	67.55	39.00	67.38	39.29	67.21	39.59	67.03	39.88	78
79	68.42	39.50	68.24	39.80	68.07	40.10	67.89	40.39	79
80	69.28	40.00	69.11	40.30	68.93	40.60	68.75	40.90	80
81	70.15	40.50	69.97	40.81	69.79	41.11	69.61	41.41	81
82	71.01	41.00	70.83	41.31	70.65	41.62	70.47	41.93	82
83	71.88	41.50	71.70	41.81	71.52	42.13	71.33	42.44	83
84	72.75	42.00	72.56	42.32	72.38	42.63	72.19	42.95	84
85	73.61	42.50	73.43	42.82	73.24	43.14	73.05	43.46	85
86	74.48	43.00	74.29	43.32	74.10	43.65	73.91	43.97	86
87	75.34	43.50	75.15	43.83	74.96	44.16	74.77	44.48	87
88	76.21	44.00	76.02	44.33	75.82	44.66	75.63	44.99	88
89	77.08	44.50	76.88	44.84	76.68	45.17	76.49	45.51	89
90	77.94	45.00	77.75	45.34	77.55	45.68	77.35	46.02	90
91	78.81	45.50	78.61	45.84	78.41	46.19	78.21	46.53	91
92	79.67	46.00	79.47	46.35	79.27	46.69	79.07	47.04	92
93	80.54	46.50	80.34	46.85	80.13	47.20	79.92	47.55	93
94	81.41	47.00	81.20	47.35	80.99	47.71	80.78	48.06	94
95	82.27	47.50	82.06	47.86	81.85	48.22	81.64	48.57	95
96	83.14	48.00	82.93	48.36	82.72	48.72	82.50	49.08	96
97	84.00	48.50	83.79	48.87	83.58	49.23	83.36	49.60	97
98	84.87	49.00	84.66	49.37	84.44	49.74	84.22	50.11	98
99	85.74	49.50	85.52	49.87	85.30	50.25	85.08	50.62	99
100	86.60	50.00	86.38	50.38	86.16	50.75	85.94	51.13	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	31 Deg.		31¼ Deg.		31½ Deg.		31¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.86	0.51	0.85	0.52	0.85	0.52	0.85	0.53	1
2	1.71	1.03	1.71	1.04	1.71	1.04	1.70	1.05	2
3	2.57	1.55	2.56	1.56	2.56	1.57	2.55	1.58	3
4	3.43	2.06	3.42	2.08	3.41	2.09	3.40	2.10	4
5	4.29	2.58	4.27	2.59	4.26	2.61	4.25	2.63	5
6	5.14	3.09	5.13	3.11	5.12	3.13	5.10	3.16	6
7	6.00	3.61	5.98	3.63	5.97	3.66	5.95	3.68	7
8	6.86	4.12	6.84	4.15	6.82	4.18	6.80	4.21	8
9	7.71	4.64	7.69	4.67	7.67	4.70	7.65	4.74	9
10	8.57	5.15	8.55	5.19	8.53	5.22	8.50	5.26	10
11	9.43	5.67	9.40	5.71	9.38	5.75	9.35	5.79	11
12	10.29	6.18	10.26	6.23	10.23	6.27	10.20	6.31	12
13	11.14	6.70	11.11	6.74	11.08	6.79	11.05	6.84	13
14	12.00	7.21	11.97	7.26	11.94	7.31	11.90	7.37	14
15	12.86	7.73	12.82	7.78	12.79	7.84	12.76	7.89	15
16	13.71	8.24	13.68	8.30	13.64	8.36	13.61	8.42	16
17	14.57	8.76	14.53	8.82	14.49	8.88	14.46	8.95	17
18	15.43	9.27	15.39	9.34	15.35	9.40	15.31	9.47	18
19	16.29	9.79	16.24	9.86	16.20	9.93	16.16	10.00	19
20	17.14	10.30	17.10	10.38	17.05	10.45	17.01	10.52	20
21	18.00	10.82	17.95	10.89	17.91	10.97	17.86	11.05	21
22	18.86	11.33	18.81	11.41	18.76	11.49	18.71	11.58	22
23	19.71	11.85	19.66	11.93	19.61	12.02	19.56	12.10	23
24	20.57	12.36	20.52	12.45	20.46	12.54	20.41	12.63	24
25	21.43	12.88	21.37	12.97	21.32	13.06	21.26	13.16	25
26	22.29	13.39	22.23	13.49	22.17	13.58	22.11	13.68	26
27	23.14	13.91	23.08	14.01	23.02	14.11	22.96	14.21	27
28	24.00	14.42	23.94	14.53	23.87	14.63	23.81	14.73	28
29	24.86	14.94	24.79	15.04	24.73	15.15	24.66	15.26	29
30	25.71	15.45	25.65	15.56	25.58	15.67	25.51	15.79	30
31	26.57	15.97	26.50	16.08	26.43	16.20	26.36	16.31	31
32	27.43	16.48	27.36	16.60	27.28	16.72	27.21	16.84	32
33	28.29	17.00	28.21	17.12	28.14	17.24	28.06	17.37	33
34	29.14	17.51	29.07	17.64	28.99	17.76	28.91	17.89	34
35	30.00	18.03	29.92	18.16	29.84	18.29	29.76	18.42	35
36	30.86	18.54	30.78	18.68	30.70	18.81	30.61	18.94	36
37	31.72	19.06	31.63	19.19	31.55	19.33	31.46	19.47	37
38	32.57	19.57	32.49	19.71	32.40	19.85	32.31	20.00	38
39	33.43	20.09	33.34	20.23	33.25	20.38	33.16	20.52	39
40	34.29	20.60	34.20	20.75	34.11	20.90	34.01	21.05	40
41	35.14	21.12	35.05	21.27	34.96	21.42	34.86	21.57	41
42	36.00	21.63	35.91	21.79	35.81	21.94	35.71	22.10	42
43	36.86	22.15	36.76	22.31	36.66	22.47	36.57	22.63	43
44	37.72	22.66	37.62	22.83	37.52	22.99	37.42	23.15	44
45	38.57	23.18	38.47	23.34	38.37	23.51	38.27	23.68	45
46	39.43	23.69	39.33	23.86	39.22	24.03	39.12	24.21	46
47	40.29	24.21	40.18	24.38	40.07	24.56	39.97	24.73	47
48	41.14	24.72	41.04	24.90	40.93	25.08	40.82	25.26	48
49	42.00	25.24	41.89	25.42	41.78	25.60	41.67	25.78	49
50	42.86	25.75	42.75	25.94	42.63	26.12	42.52	26.31	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	31 Deg.		31¼ Deg.		31½ Deg.		31¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.72	26.27	43.60	26.46	43.48	26.65	43.37	26.84	51
52	44.57	26.78	44.46	26.98	44.34	27.17	44.22	27.36	52
53	45.43	27.30	45.31	27.49	45.19	27.69	45.07	27.89	53
54	46.29	27.81	46.17	28.01	46.04	28.21	45.92	28.42	54
55	47.14	28.33	47.02	28.53	46.90	28.74	46.77	28.94	55
56	48.00	28.84	47.88	29.05	47.75	29.26	47.62	29.47	56
57	48.86	29.36	48.73	29.57	48.60	29.78	48.47	29.99	57
58	49.72	29.87	49.58	30.09	49.45	30.30	49.32	30.52	58
59	50.57	30.39	50 44	30.61	50.31	30.83	50.17	31.05	59
60	51.43	30.90	51.29	31.13	51.16	31.35	51.02	31.57	60
61	52.29	31.42	52.15	31.65	52.01	31.87	51.87	32.10	61
62	53.14	31.93	53.00	32.16	52.86	32.39	52.72	32.63	62
63	54.00	32.45	53.86	32.68	53.72	32.92	53.57	33.15	63
64	54.86	32.96	54.71	33.20	54.57	33.44	54.42	33.68	64
65	55.72	33.48	55.57	33.72	55.42	33.96	55.27	34.20	65
66	56.57	33.99	56.42	34.24	56.27	34.48	56.12	34.73	66
67	57.43	34.51	57.28	34.76	57.13	35.01	56.98	35.26	67
68	58.29	35.02	58.13	35.28	57.98	35.53	57.82	35.78	68
69	59.14	35.54	58.99	35.80	58.83	36.05	58.67	36.31	69
70	60.00	36.05	59.84	36.31	59.68	36.57	59.52	36.83	70
71	60.86	36.57	60.70	36.83	60.54	37.10	60.37	37.36	71
72	61.72	37.08	61.55	37.35	61.39	37.62	61.23	37.89	72
73	62.57	37.60	62.41	37.87	62.24	38.14	62.08	38.41	73
74	63.43	38.11	63.26	38.39	63.10	38.66	62.93	38.94	74
75	64.29	38.63	64.12	38.91	63.95	39.19	63.78	39.47	75
76	65.14	39.14	64.97	39.43	64.80	39.71	64.63	39.99	76
77	66.00	39.66	65.83	39.95	65.65	40.23	65.48	40.52	77
78	66.86	40.17	66.68	40.46	66.51	40.75	66.33	41.04	78
79	67.72	40.69	67.54	40.98	67.36	41.28	67.18	41.57	79
80	68.57	41.20	68.39	41.50	68.21	41.80	68.03	42.10	80
81	69.43	41.72	69.25	42.02	69.06	42.32	68.88	42.62	81
82	70.29	42.23	70.10	42.54	69.92	42.84	69.73	43.15	82
83	71.14	42.75	70.96	43.06	70.77	43.37	70.58	43.68	83
84	72.00	43.26	71.81	43.58	71.62	43.89	71.43	44.20	84
85	72.86	43.78	72.67	44.10	72.47	44.41	72.28	44.73	85
86	73.72	44.29	73.52	44.61	73.33	44.93	73.13	45.25	86
87	74.57	44.81	74.38	45.13	74.18	45.46	73.98	45.78	87
88	75.43	45.32	75.23	45.65	75.03	45.98	74.83	46.31	88
89	76.29	45.84	76.09	46.17	75.88	46.50	75.68	46.83	89
90	77.15	46.35	76.94	46.69	76.74	47.02	76.53	47.36	90
91	78.00	46.87	77.80	47.21	77.59	47.55	77.38	47.89	91
92	78.86	47.38	78.65	47.73	78.44	48.07	78.23	48.41	92
93	79.72	47.90	79.51	48.25	79.30	48.59	79.08	48.94	93
94	80.57	48.41	80.36	48.76	80.15	49.11	79 93	49.47	94
95	81.43	48.93	81.22	49.28	81.00	49.64	80 78	49.99	95
96	82.29	49.44	82.07	49.80	81.85	50.16	81.63	50.52	96
97	83.15	49.96	82.93	50.32	82.71	50 .68	82.48	51.04	97
98	84.00	50.47	83.78	50.84	83.56	51.20	83.33	51.57	98
99	84.86	50.99	84.64	51.36	84.41	51.73	84.18	52.10	99
100	85.72	51.50	85.49	51.88	85.26	52.25	85.04	52.62	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.85	0.53	0.85	0.53	0.84	0.54	0.84	0.54	1
2	1.70	1.06	1.69	1.07	1.69	1.07	1.68	1.08	2
3	2.54	1.59	2.54	1.60	2.53	1.61	2.52	1.62	3
4	3.39	2.12	3.38	2.13	3.37	2.15	3.36	2.16	4
5	4.24	2.65	4.23	2.67	4.22	2.69	4.21	2.70	5
6	5.09	3.18	5.07	3.20	5.06	3.22	5.05	3.25	6
7	5.94	3.71	5.92	3.74	5.90	3.76	5.89	3.79	7
8	6.78	4.24	6.77	4.27	6.75	4.30	6.73	4.33	8
9	7.63	4.77	7.61	4.80	7.59	4.84	7.57	4.87	9
10	8.48	5.30	8.46	5.34	8.43	5.37	8.41	5.41	10
11	9.33	5.83	9.30	5.87	9.28	5.91	9.25	5.95	11
12	10.18	6.36	10.15	6.40	10.12	6.45	10.09	6.49	12
13	11.02	6.89	10.99	6.94	10.96	6.98	10.93	7.03	13
14	11.87	7.42	11.84	7.47	11.81	7.52	11.77	7.57	14
15	12.72	7.95	12.69	8.00	12.65	8.06	12.62	8.11	15
16	13.57	8.48	13.53	8.54	13.49	8.60	13.46	8.66	16
17	14.42	9.01	14.38	9.07	14.34	9.13	14.30	9.20	17
18	15.26	9.54	15.22	9.61	15.18	9.67	15.14	9.74	18
19	16.11	10.07	16.07	10.14	16.02	10.21	15.98	10.28	19
20	16.96	10.60	16.91	10.67	16.87	10.75	16.82	10.82	20
21	17.81	11.13	17.76	11.21	17.71	11.28	17.66	11.36	21
22	18.66	11.66	18.61	11.74	18.55	11.82	18.50	11.90	22
23	19.51	12.19	19.45	12.27	19.40	12.36	19.34	12.44	23
24	20.35	12.72	20.30	12.81	20.24	12.90	20.18	12.98	24
25	21.20	13.25	21.14	13.34	21.08	13.43	21.03	13.52	25
26	22.05	13.78	21.99	13.87	21.93	13.97	21.87	14.07	26
27	22.90	14.31	22.83	14.41	22.77	14.51	22.71	14.61	27
28	23.75	14.84	23.68	14.94	23.61	15.04	23.55	15.15	28
29	24.59	15.37	24.53	15.47	24.46	15.58	24.39	15.69	29
30	25.44	15.90	25.37	16.01	25.30	16.12	25.23	16.23	30
31	26.29	16.43	26.22	16.54	26.15	16.66	26.07	16.77	31
32	27.14	16.96	27.06	17.08	26.99	17.19	26.91	17.31	32
33	27.99	17.49	27.91	17.61	27.83	17.73	27.75	17.85	33
34	28.83	18.02	28.75	18.14	28.68	18.27	28.60	18.39	34
35	29.68	18.55	29.60	18.68	29.52	18.81	29.44	18.93	35
36	30.53	19.08	30.45	19.21	30.36	19.34	30.28	19.48	36
37	31.38	19.61	31.29	19.74	31.21	19.88	31.12	20.02	37
38	32.23	20.14	32.14	20.28	32.05	20.42	31.96	20.56	38
39	33.07	20.67	32.98	20.81	32.89	20.95	32.80	21.10	39
40	33.92	21.20	33.83	21.34	33.74	21.49	33.64	21.64	40
41	34.77	21.73	34.67	21.88	34.58	22.03	34.48	22.18	41
42	35.62	22.26	35.52	22.41	35.42	22.57	35.32	22.72	42
43	36.47	22.79	36.37	22.95	36.27	23.10	36.16	23.26	43
44	37.31	23.32	37.21	23.48	37.11	23.64	37.01	23.80	44
45	38.16	23.85	38.06	24.01	37.95	24.18	37.85	24.34	45
46	39.01	24.38	38.90	24.55	38.80	24.72	38.69	24.88	46
47	39.86	24.91	39.75	25.08	39.64	25.25	39.53	25.43	47
48	40.71	25.44	40.59	25.61	40.48	25.79	40.37	25.97	48
49	41.55	25.97	41.44	26.15	41.33	26.33	41.21	26.51	49
50	42.40	26.50	42.29	26.68	42.17	26.86	42.05	27.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.25	27.03	43.13	27.21	43.01	27.40	42.89	27.59	51
52	44.10	27.56	43.98	27.75	43.86	27.94	43.73	28.13	52
53	44.95	28.09	44.82	28.28	44.70	28.48	44.58	28.67	53
54	45.79	28.62	45.67	28.82	45.54	29.01	45.42	29.21	54
55	46.64	29.15	46.51	29.35	46.39	29.55	46.26	29.75	55
56	47.49	29.68	47.36	29.88	47.23	30.09	47.10	30.29	56
57	48.34	30.21	48.21	30.42	48.07	30.63	47.94	30.84	57
58	49.19	30.74	49.05	30.95	48.92	31.16	48.78	31.38	58
59	50.03	31 27	49.90	31.48	49.76	31.70	49.62	31.92	59
60	50.88	31.80	50.74	32.02	50.60	32.24	50.46	32.46	60
61	51.73	32.33	51.59	32.55	51.45	32.78	51.30	33.00	61
62	52.58	32.85	52.44	33.08	52.29	33.31	52.14	33.54	62
63	53.43	33.38	53.28	33.62	53.13	33.85	52.99	34.08	63
64	54.28	33.91	54.13	34.15	53.98	34.39	53.83	34.62	64
65	55.12	34.44	54.97	34.68	54.82	34.92	54.67	35.16	65
66	55.97	34.97	55.82	35.22	55.66	35.46	55.51	35.70	66
67	56.82	35.50	56.66	35.75	56.51	36.00	56.35	36.25	67
68	57.67	36.03	57.51	36.29	57.35	36.54	57.19	36.79	68
69	58.52	36.56	58.36	36.82	58.19	37.07	58.03	37.33	69
70	59.36	37.09	59.20	37.35	59.04	37.61	58.87	37.87	70
71	60.21	37.62	60.05	37.89	59.88	38.15	59.71	38.41	71
72	61.06	38.15	60.89	38.42	60.72	38.69	60.55	38.95	72
73	61.91	38.68	61.74	38.95	61.57	39.22	61.40	39.49	73
74	62.76	39.21	62.58	39.49	62.41	39.76	62.24	40.03	74
75	63.60	39.74	63.43	40.02	63.25	40.30	63.08	40.57	75
76	64.45	40.27	64.28	40.55	64.10	40.83	63.92	41.11	76
77	65.30	40.80	65.12	41.09	64.94	41.37	64.76	41.65	77
78	66.15	41.33	65.97	41.62	65.78	41.91	65.60	42.20	78
79	67.00	41.86	66.81	42.16	66.63	42 45	66.44	42.74	79
80	67.84	42.39	67.66	42.69	67.47	42.98	67.28	43.28	80
81	68.69	42.92	68.50	43.22	68.31	43.52	68.12	43.82	81
82	69.54	43.45	69.35	43.76	69.16	44.06	68.97	44.36	82
83	70.39	43.98	70.20	44.29	70.00	44.60	69.81	44.90	83
84	71.24	44.51	71.04	44.82	70.84	45.13	70.65	45.44	84
85	72.08	45.04	71.89	45.36	71.69	45.67	71.49	45.98	85
86	72.93	45.57	72.73	45.89	72.53	46.21	72.33	46.52	86
87	73.78	46.10	73.58	46.42	73.38	46.75	73.17	47.06	87
88	74.63	46.63	74.42	46.96	74.22	47.28	74.01	47.61	88
89	75.48	47.16	75.27	47.49	75.06	47.82	74.85	48.15	89
90	76.32	47.69	76.12	48.03	75.91	48.36	75.69	48.69	90
91	77.17	48.22	76.96	48.56	76.75	48.89	76.53	49.23	91
92	78.02	48.75	77.81	49.09	77.59	49.43	77.38	49 77	92
93	78.87	49.28	78.65	49.63	78.44	49.97	78.22	50.31	93
94	79.72	49.81	79.50	50.16	79.28	50.51	79.06	50.85	94
95	80.56	50.34	80.34	50.69	80.12	51.04	79.90	51.39	95
96	81.41	50.87	81.19	51.23	80.97	51.58	80.74	51.93	96
97	82.26	51.40	82.04	51.76	81.81	52.12	81.58	52.47	97
98	83.11	51.93	82.88	52.29	82.65	52.66	82.42	53.02	98
99	83.96	52.46	83.73	52.83	83.50	53.19	83.26	53.56	99
100	84.80	52.99	84.57	53.36	84.34	53.73	84.10	54.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.84	0.54	0.84	0.55	0.83	0.55	0.83	0.56	1
2	1.68	1.09	1.67	1.10	1.67	1.10	1.66	1.11	2
3	2.52	1.63	2.51	1.64	2.50	1.66	2.49	1.67	3
4	3.35	2.18	3.35	2.19	3.34	2.21	3.33	2.22	4
5	4.19	2.72	4.18	2.74	4.17	2.76	4.16	2.78	5
6	5.03	3.27	5.02	3.29	5.00	3.31	4.99	3.33	6
7	5.87	3.81	5.85	3.84	5.84	3.86	5.82	3.89	7
8	6.71	4.36	6.69	4.39	6.67	4.42	6.65	4.44	8
9	7.55	4.90	7.53	4.93	7.50	4.97	7.48	5.00	9
10	8.39	5.45	8.36	5.48	8.34	5.52	8.31	5.56	10
11	9.23	5.99	9.20	6.03	9.17	6.07	9.15	6.11	11
12	10.06	6.54	10.04	6.58	10.01	6.62	9.98	6.67	12
13	10.90	7.08	10.87	7.13	10.84	7.18	10.81	7.22	13
14	11.74	7.62	11.71	7.68	11.67	7.73	11.64	7.78	14
15	12.58	8.17	12.54	8.22	12.51	8.28	12.47	8.33	15
16	13.42	8.71	13.38	8.77	13.34	8.83	13.30	8.89	16
17	14.26	9.26	14.22	9.32	14.18	9.38	14.13	9.44	17
18	15.10	9.80	15.05	9.87	15.01	9.93	14.97	10.00	18
19	15.93	10.35	15.89	10.42	15.84	10.49	15.80	10.56	19
20	16.77	10.89	16.73	10.97	16.68	11.04	16.63	11.11	20
21	17.61	11.44	17.56	11.51	17.51	11.59	17.46	11.67	21
22	18.45	11.98	18.40	12.06	18.35	12.14	18.29	12.22	22
23	19.29	12.53	19.23	12.61	19.18	12.69	19.12	12.78	23
24	20.13	13.07	20.07	13.16	20.01	13.25	19.96	13.33	24
25	20.97	13.62	20.91	13.71	20.85	13.80	20.79	13.89	25
26	21.81	14.16	21.74	14.26	21.68	14.35	21.62	14.44	26
27	22.64	14.71	22.58	14.80	22.51	14.90	22.45	15.00	27
28	23.48	15.25	23.42	15.35	23.35	15.45	23.28	15.56	28
29	24.32	15.79	24.25	15.90	24.18	16.01	24.11	16.11	29
30	25.16	16.34	25.09	16.45	25.02	16.56	24.94	16.67	30
31	26.00	16.88	25.92	17.00	25.85	17.11	25.78	17.22	31
32	26.84	17.43	26.76	17.55	26.68	17.66	26.61	17.78	32
33	27.68	17.97	27.60	18.09	27.52	18.21	27.44	18.33	33
34	28.51	18.52	28.43	18.64	28.35	18.77	28.27	18.89	34
35	29.35	19.06	29.27	19.19	29.19	19.32	29.10	19.44	35
36	30.19	19.61	30.11	19.74	30.02	19.87	29.93	20.00	36
37	31.03	20.15	30.94	20.29	30.85	20.42	30.76	20.56	37
38	31.87	20.70	31.78	20.84	31.69	20.97	31.60	21.11	38
39	32.71	21.24	32.62	21.38	32.52	21.53	32.43	21.67	39
40	33.55	21.79	33.45	21.93	33.36	22.08	33.26	22.22	40
41	34.39	22.33	34.29	22.48	34.19	22.63	34.09	22.78	41
42	35.22	22.87	35.12	23.03	35.02	23.18	34.92	23.33	42
43	36.06	23.42	35.96	23.58	35.86	23.73	35.75	23.89	43
44	36.90	23.96	36.80	24.12	36.69	24.29	36.58	24.45	44
45	37.74	24.51	37.63	24.67	37.52	24.84	37.42	25.00	45
46	38.58	25.05	38.47	25.22	38.36	25.39	38.25	25.56	46
47	39.42	25.60	39.31	25.77	39.19	25.94	39.08	26.11	47
48	40.26	26.14	40.14	26.32	40.03	26.49	39.91	26.67	48
49	41.09	26.69	40.98	26.87	40.86	27.04	40.74	27.22	49
50	41.93	27.23	41.81	27.41	41.69	27.60	41.57	27.78	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg.		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	42.77	27.78	42.65	27.96	42.53	28.15	42.40	28.33	51
52	43.61	28.32	43.49	28.51	43.36	28.70	43.24	28.89	52
53	44.45	28.87	44.32	29.06	44.20	29.25	44.07	29.45	53
54	45.29	29.41	45.16	29.61	45.03	29.80	44.90	30.00	54
55	46.13	29.96	46.00	30.16	45.86	30.36	45.73	30.56	55
56	46.97	30.50	46.83	30.70	46.70	30.91	46.56	31.11	56
57	47.80	31.04	47.67	31.25	47.53	31.46	47.39	31.67	57
58	48.64	31.59	48.50	31.80	48.37	32.01	48.23	32.22	58
59	49.48	32.13	49.34	32.35	49.20	32.56	49.06	32.78	59
60	50.32	32.68	50.18	32.90	50.03	33.12	49.89	33.33	60
61	51.16	33.22	51.01	33.45	50.87	33.67	50.72	33.89	61
62	52.00	33.77	51.85	33.99	51.70	34.22	51.55	34.45	62
63	52.84	34.31	52.69	34.54	52.53	34.77	52.38	35.00	63
64	53.67	34.86	53.52	35.09	53.37	35.32	53.21	35.56	64
65	54.51	35.40	54.36	35.64	54.20	35.88	54.05	36.11	65
66	55.35	35.95	55.19	36.19	55.04	36.43	54.88	36.67	66
67	56.19	36.49	56.03	36.74	55.87	36.98	55.71	37.22	67
68	57.03	37.04	56.87	37.28	56.70	37.53	56.54	37.78	68
69	57.87	37.58	57.70	37.83	57.54	38.08	57.37	38.33	69
70	58.71	38.12	58.54	38.38	58.37	38.64	58.20	38.89	70
71	59.55	38.67	59.38	38.93	59.21	39.19	59.03	39.45	71
72	60.38	39.21	60.21	39.48	60.04	39.74	59.87	40.00	72
73	61.22	39.76	61.05	40.03	60.87	40.29	60.70	40.56	73
74	62.06	40.30	61.89	40.57	61.71	40.84	61.53	41.11	74
75	62.90	40.85	62.72	41.12	62.54	41.40	62.36	41.67	75
76	63.74	41.39	63.56	41.67	63.38	41.95	63.19	42.22	76
77	64.58	41.94	64.39	42.22	64.21	42.50	64.02	42.78	77
78	65.42	42.48	65.23	42.77	65.04	43.05	64.85	43.33	78
79	66.25	43.03	66.07	43.32	65.88	43.60	65.69	43.89	79
80	67.09	43.57	66.90	43.86	66.71	44.15	66.52	44.45	80
81	67.93	44.12	67.74	44.41	67.54	44.71	67.35	45.00	81
82	68.77	44.66	68.58	44.96	68.38	45.26	68.18	45.56	82
83	69.61	45.20	69.41	45.51	69.21	45.81	69.01	46.11	83
84	70.45	45.75	70.25	46.06	70.05	46.36	69.84	46.67	84
85	71.29	46.29	71.08	46.60	70.88	46.91	70.67	47.22	85
86	72.13	46.84	71.92	47.15	71.71	47.47	71.51	47.78	86
87	72.96	47.38	72.76	47.70	72.55	48.02	72.34	48.33	87
88	73.80	47.93	73.59	48.25	73.38	48.57	73.17	48.89	88
89	74.64	48.47	74.43	48.80	74.22	49.12	74.00	49.45	89
90	75.48	49.02	75.27	49.35	75.05	49.67	74.83	50.00	90
91	76.32	49.56	76.10	49.89	75.88	50.23	75.66	50.56	91
92	77.16	50.11	76.94	50.44	76.72	50.78	76.50	51.11	92
93	78.00	50.65	77.77	50.99	77.55	51.33	77.33	51.67	93
94	78.83	51.20	78.61	51.54	78.39	51.88	78.16	52.22	94
95	79.67	51.74	79.45	52.09	79.22	52.43	78.99	52.78	95
96	80.51	52.29	80.28	52.64	80.05	52.99	79.82	53.33	96
97	81.35	52.83	81.12	53.18	80.89	53.54	80.65	53.89	97
98	82.19	53.37	81.96	53.73	81.72	54.09	81.48	54.45	98
99	83.03	53.92	82.79	54.28	82.55	54.64	82.32	55.00	99
100	83.87	54.46	83.63	54.83	83.39	55.19	83.15	55.56	00
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	34 Deg.		34¼ Deg.		34½ Deg.		34¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.83	0.56	0.83	0.56	0.82	0.57	0.82	0.57	1
2	1.66	1.12	1.65	1.13	1.65	1.13	1.64	1.14	2
3	2.49	1.68	2.48	1.69	2.47	1.70	2.46	1.71	3
4	3.32	2.24	3.31	2.25	3.30	2.27	3.29	2.28	4
5	4.15	2.80	4.13	2.81	4.12	2.83	4.11	2.85	5
6	4.97	3.36	4.96	3.38	4.94	3.40	4.93	3.42	6
7	5.80	3.91	5.79	3.94	5.77	3.96	5.75	3.99	7
8	6.63	4.47	6.61	4.50	6.59	4.53	6.57	4.56	8
9	7.46	5.03	7.44	5.07	7.42	5.10	7.39	5.13	9
10	8.29	5.59	8.27	5.63	8.24	5.66	8.22	5.70	10
11	9.12	6.15	9.09	6.19	9.07	6.23	9.04	6.27	11
12	9.95	6.71	9.92	6.75	9.89	6.80	9.86	6.84	12
13	10.78	7.27	10.75	7.32	10.71	7.36	10.68	7.41	13
14	11.61	7.83	11.57	7.88	11.54	7.93	11.50	7.98	14
15	12.44	8.39	12.40	8.44	12.36	8.50	12.32	8.55	15
16	13.26	8.95	13.23	9.00	13.19	9.06	13.15	9.12	16
17	14.09	9.51	14.05	9.57	14.01	9.63	13.97	9.69	17
18	14.92	10.07	14.88	10.13	14.83	10.20	14.79	10.26	18
19	15.75	10.62	15.71	10.69	15.66	10.76	15.61	10.83	19
20	16.58	11.18	16.53	11.26	16.48	11.33	16.43	11.40	20
21	17.41	11.74	17.36	11.82	17.31	11.89	17.25	11.97	21
22	18.24	12.30	18.18	12.38	18.13	12.46	18.08	12.54	22
23	19.07	12.86	19.01	12.94	18.95	13.03	18.90	13.11	23
24	19.90	13.42	19.84	13.51	19.78	13.59	19.72	13.68	24
25	20.73	13.98	20.66	14.07	20.60	14.16	20.54	14.25	25
26	21.55	14.54	21.49	14.63	21.43	14.73	21.36	14.82	26
27	22.38	15.10	22.32	15.20	22.25	15.29	22.18	15.39	27
28	23.21	15.66	23.14	15.76	23.08	15.86	23.01	15.96	28
29	24.04	16.22	23.97	16.32	23.90	16.43	23.83	16.53	29
30	24.87	16.78	24.80	16.88	24.72	16.99	24.65	17.10	30
31	25.70	17.33	25.62	17.45	25.55	17.56	25.47	17.67	31
32	26.53	17.89	26.45	18.01	26.37	18.12	26.29	18.24	32
33	27.36	18.45	27.28	18.57	27.20	18.69	27.11	18.81	33
34	28.19	19.01	28.10	19.14	28.02	19.26	27.94	19.38	34
35	29.02	19.57	28.93	19.70	28.84	19.82	28.76	19.95	35
36	29.85	20.13	29.76	20.26	29.67	20.39	29.58	20.52	36
37	30.67	20.69	30.58	20.82	30.49	20.96	30.40	21.09	37
38	31.50	21.25	31.41	21.39	31.32	21.52	31.22	21.66	38
39	32.33	21.81	32.24	21.95	32.14	22.09	32.04	22.23	39
40	33.16	22.37	33.06	22.51	32.97	22.66	32.87	22.80	40
41	33.99	22.93	33.89	23.07	33.79	23.22	33.69	23.37	41
42	34.82	23.49	34.72	23.64	34.61	23.79	34.51	23.94	42
43	35.65	24.05	35.54	24.20	35.44	24.36	35.33	24.51	43
44	36.48	24.60	36.37	24.76	36.26	24.92	36.15	25.08	44
45	37.31	25.16	37.20	25.33	37.09	25.49	36.97	25.65	45
46	38.14	25.72	38.02	25.89	37.91	26.05	37.80	26.22	46
47	38.96	26.28	38.85	26.45	38.73	26.62	38.62	26.79	47
48	39.79	26.84	39.68	27.01	39.56	27.19	39.44	27.36	48
49	40.62	27.40	40.50	27.58	40.38	27.75	40.26	27.93	49
50	41.45	27.96	41.33	28.14	41.21	28.32	41.08	28.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	34 Deg.		34¼ Deg.		34½ Deg.		34¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	42.28	28.52	42.16	28 70	42.03	28.89	41.90	29.07	51
52	43.11	29.08	42.98	29.27	42.85	29.45	42.73	29.64	52
53	43.94	29.64	43.81	29.83	43.68	30.02	43.55	30.21	53
54	44.77	30.20	44.64	30.39	44.50	30.59	44.37	30 78	54
55	45.60	30.76	45.46	30.95	45.33	31.15	45.19	31.35	55
56	46.43	31.31	46.29	31.52	46.15	31.72	46 01	31.92	56
57	47.26	31.87	47.12	32.08	46.98	32 29	46.83	32.49	57
58	48.08	32.43	47.94	32.64	47.80	32.85	47.66	33.06	58
59	48.91	32.99	48.77	33.21	48.62	33.42	48.48	33.63	59
60	49.74	33.55	49.60	33.77	49.45	33.98	49.30	34.20	60
61	50.57	34.11	50.42	34.33	50.27	34.55	50.12	34.77	61
62	51.40	34.67	51.25	34.89	51.10	35.12	50.94	35.34	62
63	52.23	35.23	52.08	35.46	51.92	35.68	51.76	35.91	63
64	53.06	35.79	52.90	36.02	52.74	36.25	52.59	36.48	64
65	53.89	36.35	53.73	36.58	53.57	36.82	53.41	37.05	65
66	54.72	36.91	54.55	37.15	54.39	37.38	54.23	37.62	66
67	55.55	37.46	55.38	37.71	55.22	37.95	55.05	38.19	67
68	56.37	38.03	56.21	38.27	56.04	38.52	55.87	38.76	68
69	57.20	38.58	57.03	38.83	56.86	39.08	56.69	39.33	69
70	58.03	39.14	57.86	39.40	57.69	39.65	57.52	39.90	70
71	58.86	39.70	58.69	39.96	58.51	40.21	58.34	40.47	71
72	59.69	40.26	59.51	40.52	59.34	40.78	59.16	41.04	72
73	60.52	40.82	60.34	41.08	60.16	41.35	59.98	41.61	73
74	61.35	41.38	61.17	41.65	60.99	41.91	60.80	42.18	74
75	62.18	41.94	61.99	42.21	61.81	42.48	61.62	42.75	75
76	63.01	42.50	62.82	42.77	62.63	43.05	62.45	43.32	76
77	63.84	43.06	63.65	43.34	63.46	43.61	63.27	43.89	77
78	64.66	43.62	64.47	43.90	64.28	44.18	64.09	44.46	78
79	65.49	44.18	65.30	44.46	65.11	44.75	64.91	45.03	79
80	66.32	44.74	66.13	45.02	65.93	45.31	65.73	45.60	80
81	67.15	45.29	66.95	45.59	66.75	45.88	66.55	46.17	81
82	67.98	45.85	67.78	46.15	67.58	46.45	67.37	46.74	82
83	68.81	46.41	68.61	46.71	68.40	47.01	68.20	47.31	83
84	69.64	46.97	69.43	47.28	69.23	47.58	69.02	47.88	84
85	70.47	47.53	70.26	47.84	70.05	48.14	69.84	48.45	85
86	71.30	48.09	71.09	48.40	70.87	48.71	70.66	49.02	86
87	72.13	48.65	71.91	48.96	71.70	49.28	71.48	49.59	87
88	72.96	49.21	72.74	49.53	72.52	49.84	72.30	50.16	88
89	73.78	49.77	73.57	50.09	73.35	50.41	73.13	50 73	89
90	74.61	50.33	74.39	50.65	74.17	50.98	73.95	51.30	90
91	75.44	50.89	75.22	51.22	75.00	51.54	74.77	51.87	91
92	76.27	51.45	76.05	51.78	75.82	52.11	75.59	52.44	92
93	77.10	52.00	76.87	52.34	76.64	52.68	76.41	53.01	93
94	77.93	52.56	77.70	52.90	77.47	53.24	77.23	53.58	94
95	78.76	53.12	78.53	53.47	78.29	53.81	78.06	54.15	95
96	79.59	53.68	79.35	54.03	79.12	54.37	78.88	54.72	96
97	80.42	54.24	80.18	54.59	79.94	54.94	79 70	55.29	97
98	81.25	54.80	81.01	55.15	80.76	55.51	80 52	55.86	98
99	82.07	55.36	81.83	55.72	81.59	56.07	81.34	56.43	99
100	82.90	55.92	82.66	56.28	82.41	56.64	82.16	57.00	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	35 Deg.		35¼ Deg		35½ Deg.		35¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.82	0.57	0.82	0.58	0.81	0.58	0.81	0.58	1
2	1.64	1.15	1.63	1.15	1.63	1.16	1.62	1.17	2
3	2.46	1.72	2.45	1.73	2.44	1.74	2.43	1.75	3
4	3.28	2.29	3.27	2.31	3.26	2.32	3.25	2.34	4
5	4.10	2.87	4.08	2.89	4.07	2.90	4.06	2.92	5
6	4.91	3.44	4.90	3.46	4.88	3.48	4.87	3.51	6
7	5.73	4.01	5.72	4.04	5.70	4.06	5.68	4.09	7
8	6.55	4.59	6.53	4.62	6.51	4.65	6.49	4.67	8
9	7.37	5.16	7.35	5.19	7.33	5.23	7.30	5.26	9
10	8.19	5.74	8.17	5.77	8.14	5.81	8.12	5.84	10
11	9.01	6.31	8.98	6.35	8.96	6.39	8.93	6.43	11
12	9.83	6.88	9.80	6.93	9.77	6.97	9.74	7.01	12
13	10.65	7.46	10.62	7.50	10.58	7.55	10.55	7.60	13
14	11.47	8.03	11.43	8.08	11.40	8.13	11.36	8.18	14
15	12.29	8.60	12.25	8.66	12.21	8.71	12.17	8.76	15
16	13.11	9.18	13.07	9.23	13.03	9.29	12.99	9.35	16
17	13.93	9.75	13.88	9.81	13.84	9.87	13.80	9.93	17
18	14.74	10.32	14.70	10.39	14.65	10.45	14.61	10.52	18
19	15.56	10.90	15.52	10.97	15.47	11.03	15.42	11.10	19
20	16.38	11.47	16.33	11.54	16.28	11.61	16.23	11.68	20
21	17.20	12.05	17.15	12.12	17.10	12.19	17.04	12.27	21
22	18.02	12.62	17.97	12.70	17.91	12.78	17.85	12.85	22
23	18.84	13.19	18.78	13.27	18.72	13.36	18.67	13.44	23
24	19.66	13.77	19.60	13.85	19.54	13.94	19.48	14.02	24
25	20.48	14.34	20.42	14.43	20.35	14.52	20.29	14.61	25
26	21.30	14.91	21.23	15.01	21.17	15.10	21.10	15.19	26
27	22.12	15.49	22.05	15.58	21.98	15.68	21.91	15.77	27
28	22.94	16.06	22.87	16.15	22.80	16.26	22.72	16.36	28
29	23.76	16.63	23.68	16.74	23.61	16.84	23.54	16.94	29
30	24.57	17.21	24.50	17.51	24.42	17.42	24.35	17.53	30
31	25.39	17.78	25.32	17.89	25.24	18.00	25.16	18.11	31
32	26.21	18.35	26.13	18.47	26.05	18.58	25.97	18.70	32
33	27.03	18.93	26.95	19.05	26.87	19.16	26.78	19.28	33
34	27.85	19.50	27.77	19.62	27.68	19.74	27.59	19.86	34
35	28.67	20.08	28.58	20.20	28.49	20.32	28.41	20.45	35
36	29.49	20.65	29.40	20.78	29.31	20.91	29.22	21.03	36
37	30.31	21.22	30.22	21.35	30.12	21.49	30.03	21.62	37
38	31.13	21.80	31.03	21.93	30.94	22.07	30.84	22.20	38
39	31.95	22.37	31.85	22.51	31.75	22.65	31.65	22.79	39
40	32.77	22.94	32.67	23.09	32.56	23.23	32.46	23.37	40
41	33.59	23.52	33.48	23.66	33.38	23.81	33.27	23.95	41
42	34.40	24.09	34.30	24.24	34.19	24.39	34.09	24.54	42
43	35.22	24.66	35.12	24.82	35.01	24.97	34.90	25.12	43
44	36.04	25.24	35.93	25.39	35.82	25.55	35.71	25.71	44
45	36.86	25.81	36.75	25.97	36.64	26.13	36.52	26.29	45
46	37.68	26.38	37.57	26.55	37.45	26.71	37.33	26.88	46
47	38.50	26.96	38.38	27.13	38.26	27.29	38.14	27.46	47
48	39.32	27.53	39.20	27.70	39.08	27.87	38.96	28.04	48
49	40.14	28.11	40.02	28.28	39.89	28.45	39.77	28.63	49
50	40.96	28.68	40.83	28.86	40.71	29.04	40.58	29.21	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.		

Distance.	35 Deg.		35¼ Deg.		35½ Deg.		35¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.78	29.25	41.65	29.43	41.52	29.62	41.39	29.80	51
52	42.60	29.82	42.47	30.01	42.33	30.20	42.20	30.38	52
53	43.42	30.40	43.28	30.59	43.15	30.78	43.01	30.97	53
54	44.22	30.97	44.10	31.17	43.96	31.36	43.82	31.55	54
55	45.05	31.55	44.92	31.74	44.78	31.94	44.64	32.13	55
56	45.87	32.12	45.73	32.32	45.59	32.52	45.45	32.72	56
57	46.69	32.69	46.55	32.90	46.40	33.10	46.26	33.30	57
58	47.51	33.27	47.37	33.47	47.22	33.68	47.07	33.89	58
59	48.33	33.84	48.18	34.05	48.03	34.26	47.88	34.47	59
60	49.15	34.41	49.00	34.63	48.85	34.84	48.69	35.05	60
61	49.97	34.99	49.82	35.21	49.66	35.42	49.51	35.64	61
62	50.79	35.56	50.63	35.78	50.48	36.00	50.32	36.22	62
63	51.61	36.14	51.45	36.36	51.29	36.58	51.13	36.81	63
64	52.43	36.71	52.27	36.94	52.10	37.16	51.94	37.39	64
65	53.24	37.28	53.08	37.51	52.92	37.75	52.75	37.98	65
66	54.06	37.86	53.90	38.09	53.73	38.33	53.56	38.56	66
67	54.88	38.43	54.71	38.67	54.55	38.91	54.38	39.14	67
68	55.70	39.00	55.53	39.25	55.36	39.49	55.19	39.73	68
69	56.52	39.58	56.35	39.82	56.17	40.07	56.00	40.31	69
70	57.34	40.15	57.16	40 40	56.99	40.65	56.81	40.90	70
71	58.16	40.72	57.98	40.98	57.80	41.23	57.62	41.48	71
72	58.98	41.30	58.80	41.55	58.62	41.81	58.43	42.07	72
73	59.80	41.87	59.61	42.13	59.43	42.39	59.24	42.65	73
74	60.62	42.44	60.43	42.71	60.24	42.97	60.06	43.23	74
75	61.44	43.02	61.25	43.29	61.06	43.55	60.87	43.82	75
76	62.26	43.59	62.06	43.86	61.87	44.13	61.68	44.40	76
77	63.07	44.17	62.88	44.44	62.69	44.71	62.49	44.99	77
78	63.89	44.74	63.70	45.02	63.50	45.29	63.30	45.57	78
79	64.71	45.31	64.51	45.59	64.32	45.88	64.11	46.16	79
80	65.53	45.89	65.33	46.17	65.13	46.46	64.93	46.74	80
81	66.35	46.46	66.15	46.75	65.94	47.04	65.74	47.32	81
82	67.17	47.03	66.96	47.33	66.76	47.62	66.55	47.91	82
83	67.99	47.61	67.78	47.90	67.57	48.20	67.36	48.49	83
84	68.81	48.18	68.60	48.48	68.39	48.78	68.17	49.08	84
85	69.63	48.75	69.41	49.06	69.20	49.36	68.98	49.66	85
86	70.45	49.33	70.23	49.63	70.01	49.94	69.80	50.25	86
87	71.27	49.90	71.05	50.21	70.83	50.52	70.61	50.83	87
88	72.09	50 47	71.86	50.79	71.64	51.10	71.42	51.41	88
89	72.90	51.05	72.68	51.37	72.46	51.68	72.23	52.00	89
90	73.72	51.62	73.50	51.94	73.27	52.26	73.04	52.58	90
91	74.54	52.20	74.31	52.52	74.08	52.84	73.85	53.17	91
92	75.36	52.77	75.13	53.10	74.90	53.42	74.66	53.75	92
93	76.18	53.34	75.95	53.67	75.71	54.01	75.48	54.34	93
94	77.00	53.92	76.76	54.25	76.53	54.59	76.29	54.92	94
95	77.82	54.49	77.58	54.83	77.34	55.17	77 10	55.50	95
96	78.64	55.06	78.40	55.41	78.16	55.75	77.91	56.09	96
97	79.46	55.64	79.21	55.98	78 97	56.33	78.72	56.67	97
98	80.28	56.21	80.03	56.56	79.78	56.91	79.53	57.26	98
99	81.10	56.78	80.85	57.14	80.60	57.49	80.35	57.84	99
100	81.92	57 36	81.66	57.71	81.41	58.07	81.16	58.42	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.		

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.81	0.59	0.81	0.59	0.80	0.59	0.80	0.60	1
2	1.62	1.18	1.61	1.18	1.61	1.19	1.60	1 20	2
3	2.43	1.76	2.42	1.77	2.41	1.78	2.40	1.79	3
4	3.24	2.35	3.23	2.37	3.22	2.38	3.20	2.39	4
5	4.05	2.94	4.03	2.96	4.02	2.97	4.01	2.99	5
6	4.85	3.53	4.84	3.55	4.82	3.57	4.81	3.59	6
7	5.66	4.11	5.65	4.14	5.63	4.16	5.61	4.19	7
8	6.47	4.70	6.45	4.73	6.43	4.76	6.41	4.79	8
9	7.28	5.29	7.26	5.32	7.23	5.35	7.21	5.38	9
10	8.09	5.88	8.06	5 91	8.04	5.95	8.01	5.98	10
11	8.90	6.47	8.87	6.50	8.84	6.54	8.81	6.58	11
12	9.71	7.05	9.68	7.10	9.65	7.14	9.61	7.18	12
13	10.52	7.64	10.48	7.69	10.45	7.73	10.42	7.78	13
14	11.33	8.23	11.29	8.28	11.25	8.33	11.22	8.38	14
15	12.14	8.82	12.10	8.87	12.06	8.92	12.02	8.97	15
16	12.94	9.40	12.90	9.46	12.86	9.52	12.82	9.57	16
17	13.75	9.99	13.71	10.05	13.67	10.11	13.62	10.17	17
18	14.56	10.58	14.52	10.64	14.47	10.71	14.42	10.77	18
19	15.37	11.17	15.32	11.23	15.27	11.30	15.22	11.37	19
20	16.18	11.76	16.13	11.83	16.08	11.90	16.03	11.97	20
21	16.99	12.34	16.94	12.42	16.88	12.49	16.83	12.56	21
22	17.80	12.93	17.74	13.01	17.68	13.09	17.63	13.16	22
23	18.61	13.52	18.55	13.60	18.49	13.68	18.43	13.76	23
24	19.42	14.11	19.35	14.19	19.29	14.28	19.23	14.36	24
25	20.23	14.69	20.16	14.78	20.10	14.87	20.03	14.96	25
26	21.03	15.28	20.97	15.37	20.90	15.47	20.83	15.56	26
27	21.84	15.87	21.77	15.97	21.70	16.06	21.63	16.15	27
28	22.65	16.46	22.58	16.56	22.51	16.65	22.44	16.75	28
29	23.46	17.05	23.39	17.15	23.31	17.25	23.24	17.35	29
30	24.27	17.63	24.19	17.74	24.12	17.84	24.04	17.95	30
31	25.08	18.22	25.00	18.33	24.92	18.44	24.84	18.55	31
32	25.89	18.81	25.81	18.92	25.72	19.03	25.64	19.15	32
33	26.70	19.40	26.61	19.51	26.53	19.63	26.44	19.74	33
34	27.51	19.98	27.42	20.10	27.33	20.22	27.24	20.34	34
35	28.32	20.57	28.23	20.70	28.13	20.82	28.04	20.94	35
36	29.12	21.16	29.03	21.29	28.94	21.41	28.85	21.54	36
37	29.93	21.75	29.84	21.88	29.74	22.01	29.65	22.14	37
38	30.74	22.34	30.64	22.47	30.55	22.60	30.45	22.74	38
39	31.55	22.92	31.45	23.06	31.35	23.20	31.25	23.33	39
40	32.36	23.51	32.26	23.65	32.15	23.79	32.05	23.93	40
41	33.17	24.10	33.06	24.24	32.96	24.39	32.85	24.53	41
42	33.98	24.69	33.87	24.83	33.76	24.98	33.65	25.13	42
43	34.79	25.27	34.68	25.43	34.57	25.58	34.45	25.73	43
44	35.60	25.86	35.48	26.02	35.37	26.17	35.26	26.33	44
45	36.41	26.45	36.29	26.61	36.17	26.77	36.06	26.92	45
46	37.21	27.04	37.10	27.20	36.98	27.36	36.86	27.52	46
47	38.02	27.63	37.90	27.79	37.78	27.96	37.66	28.12	47
48	38.83	28.21	38.71	28.38	38.59	28.55	38.46	28.72	48
49	39.64	28.80	39.52	28.97	39.39	29.15	39.26	29.32	49
50	40.45	29.39	40.32	29.57	40.19	29.74	40.06	29.92	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.		

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat	Dep	Lat.	Dep.	
51	41.26	29.98	41.13	30.16	41.00	30.34	40 86	30.51	51
52	42 07	30.56	41.94	30.75	41.80	30.93	41 67	31.11	52
53	42.88	31.15	42.74	31.34	42.60	31.53	42.47	31.71	53
54	43.69	31.74	43.55	31.93	43.41	32.12	43.27	32.31	54
55	44.50	32.33	44.35	32.52	44.21	32.72	44.07	32.91	55
56	45.30	32.92	45.16	33.11	45.02	33.31	44.87	33.51	56
57	46.11	33.50	45.97	33.70	45.82	33.90	45.67	34.10	57
58	46.92	34.09	46.77	34.30	46.62	34.50	46.47	34.70	58
59	47.73	34.68	47.58	34.89	47.43	35 09	47.27	35.30	59
60	48.54	35.27	48.39	35.48	48.23	35.69	48.08	35.90	60
61	49.35	35.85	49.19	36.07	49.04	36.28	48.88	36.50	61
62	50.16	36.44	50.00	36.66	49.84	36.88	49.68	37.10	62
63	50.97	37.03	50.81	37.25	50.64	37.47	50.48	37.69	63
64	51.78	37.62	51.61	37.84	51.45	38.07	51.28	38.29	64
65	52.59	38.21	52.42	38.44	52.25	38.66	52.08	38.89	65
66	53.40	38.79	53.23	39.03	53.05	39.26	52.88	39.49	66
67	54.20	39.38	54.03	39.62	53.86	39.85	53.68	40.09	67
68	55.01	39.97	54.84	40.21	54.66	40.45	54.49	40.69	68
69	55.82	40.56	55.64	40.80	55.47	41.04	55.29	41.28	69
70	56.63	41.14	56.45	41.39	56.27	41.64	56.09	41.88	70
71	57.44	41.73	57.26	41.98	57.07	42.23	56.89	42.48	71
72	58.25	42.32	58.06	42.57	57.88	42.83	57.69	43.08	72
73	59.06	42.91	58.87	43.17	58.68	43.42	58.49	43.68	73
74	59.87	43.50	59.68	43.76	59.49	44.02	59.29	44.28	74
75	60.68	44.08	60.48	44.35	60.29	44.61	60.09	44.87	75
76	61.49	44.67	61.29	44.94	61.09	45.21	60.90	45.47	76
77	62.29	45.26	62.10	45.53	61.90	45.80	61.70	46.07	77
78	63.10	45.85	62.90	46.12	62.70	46.40	62.50	46.67	78
79	63.91	46.43	63.71	46.71	63.50	46.99	63.30	47.27	79
80	64.72	47.02	64.52	47.30	64.31	47.59	64.10	47.87	80
81	65.53	47.61	65.32	47.90	65.11	48.18	64.90	48.46	81
82	66.34	48.20	66.13	48.49	65.92	48.78	65.70	49.06	82
83	67.15	48.79	66.93	49.08	66.72	49.37	66.50	49.66	83
84	67.96	49.37	67.74	49.67	67.52	49.97	67.31	50.26	84
85	68.77	49.96	68.55	50.26	68.33	50.56	68.11	50.86	85
86	69.58	50.55	69.35	50.85	69.13	51.15	68.91	51.46	86
87	70.38	51.14	70.16	51.44	69.94	51.75	69.71	52.05	87
88	71.19	51.73	70.97	52.04	70.74	52.34	70.51	52.65	88
89	72.00	52.31	71.77	52.63	71.54	52.94	71.31	53.25	89
90	72.81	52.90	72.58	53.22	72.35	53.53	72.11	53.85	90
91	73.62	53.49	73.39	53.81	73.15	54.13	72.91	54.45	91
92	74.43	54.08	74.19	54.40	73.95	54.72	73.72	55.05	92
93	75.24	54.66	75.00	54.99	74.76	55.32	74.52	55.64	93
94	76.05	55.25	75.81	55.58	75.56	55.91	75.32	56.24	94
95	76.86	55.84	76.61	56.17	76.37	56.51	76.12	56.84	95
96	77.67	56.43	77.42	56.77	77.17	57.10	76.92	57.44	96
97	78.47	57.02	78.23	57.36	77.97	57.70	77.72	58.04	97
98	79.28	57.60	79.03	57.95	78.78	58.29	78.52	58.64	98
99	80.09	58.19	79.84	58.54	79.58	58.89	79 32	59.23	99
100	80.90	58.78	80.64	59.13	80.39	59.48	80.13	59.83	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.		

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	
1	0.80	0.60	0.80	0.61	0.79	0.61	0.79	0.61	
2	1.60	1.20	1.59	1.21	1.59	1.22	1.58	1.22	2
3	2.40	1.81	2.39	1.82	2.38	1.83	2.37	1.84	3
4	3.19	2.41	3.18	2.42	3.17	2 43	3.16	2.45	4
5	3.99	3.01	3.98	3.03	3.97	3.04	3.95	3.06	5
6	4.79	3.61	4.78	3 63	4.76	3.65	4.74	3.67	6
7	5.59	4.21	5.57	4.24	5.55	4.26	5.53	4.29	7
8	6.39	4.81	6.37	4.84	6.35	4.87	6.33	4.90	8
9	7.19	5.42	7.16	5 45	7.14	5.48	7.12	5.51	9
10	7.99	6.02	7.96	6.05	7.93	6.09	7.91	6.12	10
11	8.78	6.62	8.76	6.66	8.73	6.70	8.70	6.73	11
12	9.58	7.22	9.55	7.26	9.52	7.31	9.49	7.35	12
13	10.38	7.82	10.35	7.87	10.31	7.91	10.28	7.96	13
14	11.18	8.43	11.14	8.47	11.11	8.52	11.07	8.57	14
15	11.98	9.03	11.94	9.08	11.90	9.13	11.86	9.18	15
16	12.78	9.63	12.74	9.68	12.69	9.74	12.65	9.80	16
17	13.58	10.23	13.53	10.29	13.49	10.35	13.44	10.41	17
18	14.38	10.83	14.33	10.90	14.28	10.96	14.23	11.02	18
19	15.17	11.43	15.12	11.50	15.07	11.57	15.02	11.63	19
20	15.97	12.04	15.92	12.11	15.87	12.18	15.81	12.24	20
21	16.77	12.64	16.72	12.71	16.66	12.78	16.60	12.86	21
22	17.57	13.24	17.51	13.32	17.45	13.39	17.40	13.47	22
23	18.37	13.84	18.31	13.92	18.25	14.00	18.19	14.08	23
24	19.17	14.44	19.10	14.53	19.04	14.61	18.98	14.69	24
25	19.97	15.05	19.90	15.13	19.83	15.22	19.77	15.31	25
26	20.76	15.65	20.70	15.74	20.63	15.83	20.56	15.92	26
27	21.56	16.25	21.49	16.34	21.42	16.44	21.35	16.53	27
28	22.36	16.85	22.29	16.95	22.21	17.05	22.14	17.14	28
29	23.16	17.45	23.08	17.55	23.01	17.65	22.93	17.75	29
30	23.96	18.05	23.88	18.16	23.80	18.26	23.72	18.37	30
31	24.76	18.66	24.68	18.76	24.59	18,87	24.51	18.98	31
32	25.56	19.26	25.47	19.37	25.39	19.48	25.30	19.59	32
33	26.35	19.86	26.27	19.97	26.18	20.09	26.09	20.20	33
34	27.15	20.46	27.06	20.58	26.97	20.70	26.88	20.82	34
35	27.95	21.06	27.86	21.19	27.77	21.31	27.67	21.43	35
36	28.75	21.67	28.66	21.79	28.56	21.92	28.46	22.04	36
37	29.55	22.27	29.45	22.40	29.35	22.52	29.26	22.65	37
38	30.35	22.87	30.25	23.00	30.15	23.13	30.05	23.26	38
39	31.15	23.47	31.04	23.61	30.94	23.74	30.84	23.88	39
40	31.95	24.07	31.84	24.21	31.73	24.35	31.63	24.49	40
41	32.74	24.67	32.64	24.82	32 53	24.96	32.42	25.10	41
42	33.54	25.28	33.43	25.42	33 32	25.57	33.21	25.71	42
43	31.34	25.88	34.23	26.03	34.11	26.18	34.00	26.33	43
44	35.14	26.48	35.02	26.63	34.91	26.79	34.79	26.94	44
45	35.94	27.08	35.82	27.24	35.70	27.39	35.58	27.55	45
46	36.74	27.68	36.62	27.84	36.49	28.00	36.37	28.16	46
47	37.54	28.29	37.41	28.45	37.29	28.61	37.16	28 77	47
48	38.33	28.89	38.21	29.05	38.08	29.22	37.95	29.39	48
49	39.13	29.49	39.00	29.66	38.87	29.83	38.74	30.00	49
50	39.93	30.09	39.80	30.26	39.67	30.44	39.53	30,61	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	53 Deg.		52¾ Deg.		52½ Deg		52¼ Deg.		

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	40.73	30.69	40.60	30.87	40.46	31.05	40.33	31.22	51
52	41.53	31.29	41.39	31.48	41.25	31.66	41.12	31.84	52
53	42.33	31.90	42.19	32.08	42.05	32.26	41.91	32.45	53
54	43.13	32.50	42.98	32.69	42.84	32.87	42.70	33.06	54
55	43.92	33.10	43.78	33.29	43.63	33.48	43.49	33.67	55
56	44.72	33.70	44.58	33.90	44.43	34.09	44.28	34.28	56
57	45.52	34.30	45.37	34.50	45.22	34.70	45.07	34.90	57
58	46.32	34.91	46.17	35.11	46.01	35.31	45.86	35.51	58
59	47.12	35.51	46.96	35.71	46.81	35.92	46.65	36.12	59
60	47.92	36.11	47.76	36.32	47.60	36.53	47.44	36.73	60
61	48.72	36.71	48.56	36.92	48.39	37.13	48.23	37.35	61
62	49.52	37.31	49.35	37.53	49.19	37.74	49.02	37.96	62
63	50.31	37.91	50.15	38.13	49.98	38.35	49.81	38.57	63
64	51.11	38.52	50.94	38.74	50.77	38.96	50.60	39.18	64
65	51.91	39.12	51.74	39.34	51.57	39.57	51.39	39.79	65
66	52.71	39.72	52.54	39.95	52.36	40.18	52.19	40.41	66
67	53.51	40.32	53.33	40.55	53.15	40.79	52.98	41.02	67
68	54.31	40.92	54.13	41.16	53.95	41.40	53.77	41.63	68
69	55.11	41.53	54.92	41.77	54.74	42.00	54.56	42.24	69
70	55.90	42.13	55.72	42.37	55.53	42.61	55.35	42.86	70
71	56.70	42.73	56.52	42.98	56.33	43.22	56.14	43.47	71
72	57.50	43.33	57.31	43.58	57.12	43.83	56.93	44.08	72
73	58.30	43.93	58.11	44.19	57.91	44.44	57.72	44.69	73
74	59.10	44.53	58.90	44.79	58.71	45.05	58.51	45.30	74
75	59.90	45.14	59.70	45.40	59.50	45.66	59.30	45.92	75
76	60.70	45.74	60.50	46.00	60.29	46.27	60.09	46.53	76
77	61.49	46.34	61.29	46.61	61.09	46.87	60.88	47.14	77
78	62.29	46.94	62.09	47.21	61.88	47.48	61.67	47.75	78
79	63.09	47.54	62.88	47.82	62.67	48.09	62.46	48.37	79
80	63.89	48.15	63.68	48.42	63.47	48.70	63.26	48.98	80
81	64.69	48.75	64.48	49.03	64.26	49.31	64.05	49.59	81
82	65.49	49.35	65.27	49.63	65.05	49.92	64.84	50.20	82
83	66.29	49.95	66.07	50.24	65.85	50.53	65.63	50.81	83
84	67.09	50.55	66.86	50.84	66.64	51.14	66.42	51.43	84
85	67.88	51.15	67.66	51.45	67.43	51.74	67.21	52.04	85
86	68.68	51.76	68.46	52.06	68.23	52.35	68.00	52.65	86
87	69.48	52.36	69.25	52.66	69.02	52.96	68.79	53.26	87
88	70.28	52.96	70.05	53.27	69.82	53.57	69.58	53.88	88
89	71.08	53.56	70.84	53.87	70.61	54.18	70.37	54.49	89
90	71.88	54.16	71.64	54.48	71.40	54.79	71.16	55.10	90
91	72.68	54.77	72.44	55.08	72.20	55.40	71.95	55.71	91
92	73.47	55.37	73.23	55.69	72.99	56.01	72.74	56.32	92
93	74.27	55.97	74.03	56.29	73.78	56.61	73.53	56.94	93
94	75.07	56.57	74.82	56.90	74.58	57.22	74.32	57.55	94
95	75.87	57.17	75.62	57.50	75.37	57.83	75.12	58.16	95
96	76.67	57.77	76.42	58.11	76.16	58.44	75 91	58.77	96
97	77.47	58.38	77.21	58.71	76.96	59.05	76 70	59.39	97
98	78.27	58.98	78.01	59.32	77.75	59.66	77.49	60.00	98
99	79.06	59.58	78.80	59.92	78.54	60.27	78.28	60.61	99
100	79.86	60.18	79.60	60.53	79.34	60.88	79.07	61.22	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	53 Deg.		52¾ Deg.		52½ Deg.		52¼ Deg.		

Distance.	38 Deg.		38¼ Deg.		38½ Deg.		38¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.79	0.62	0.79	0.62	0.78	0.62	0.78	0.63	1
2	1.58	1.23	1.57	1.24	1.57	1.24	1.56	1.25	2
3	2.36	1.85	2.36	1.86	2.35	1.87	2.34	1.88	3
4	3.15	2.46	3.14	2.48	3.13	2.49	3.12	2.50	4
5	3.94	3.08	3.93	3.10	3.91	3 11	3.90	3.13	5
6	4.73	3.69	4.71	3.71	4.70	3.74	4.68	3.76	6
7	5.52	4.31	5.50	4.33	5.48	4.36	5.46	4.38	7
8	6.30	4.93	6.28	4.95	6.26	4.98	6.24	5.01	8
9	7.09	5 54	7.07	5.57	7.04	5.60	7.02	5.63	9
10	7.88	6.16	7.85	6.19	7.83	6.23	7.80	6.26	10
11	8.67	6.77	8.64	6.81	8.61	6.85	8.58	6.89	11
12	9.46	7.39	9.42	7.43	9.39	7.47	9.36	7.51	12
13	10.24	8.00	10.21	8.05	10.17	8.09	10.14	8.14	13
14	11.03	8.62	10.99	8.67	10.96	8.72	10.92	8.76	14
15	11.82	9.23	11.78	9.29	11.74	9.34	11.70	9.39	15
16	12.61	9.85	12.57	9.91	12.52	9.96	12.48	10.01	16
17	13.40	10.47	13.35	10.52	13.30	10.58	13.26	10.64	17
18	14.18	11.08	14.14	11.14	14.09	11.21	14.04	11.27	18
19	14.97	11.70	14.92	11.76	14.87	11.83	14.82	11.89	19
20	15.76	12.31	15.71	12.38	15.65	12.45	15.60	12.52	20
21	16.55	12.93	16.49	13.00	16.43	13.07	16 38	13.14	21
22	17.34	13.54	17.28	13.62	17.22	13.70	17.16	13.77	22
23	18.12	14.16	18.06	14.24	18.00	14.32	17.94	14.40	23
24	18.91	14.78	18.85	14.86	18.78	14.94	18.72	15.02	24
25	19.70	15.39	19.63	15.48	19.57	15.56	19.50	15.65	25
26	20.49	16.01	20.42	16.10	20.35	16.19	20.28	16.27	26
27	21.28	16.62	21.20	16.72	21.13	16.81	21.06	16.90	27
28	22.06	17.24	21.99	17.33	21.91	17.43	21.84	17.53	28
29	22.85	17.85	22.77	17.95	22.70	18.05	22.62	18.15	29
30	23.64	18.47	23.56	18.57	23.48	18.68	23.40	18.78	30
31	24.43	19.09	24.34	19.19	24.26	19.30	24.18	19.40	31
32	25.22	19.70	25.13	19.81	25.04	19.92	24.96	20.03	32
33	26.00	20.32	25.92	20.43	25.83	20.54	25.74	20.66	33
34	26.79	20.93	26.70	21.05	26.61	21.17	26.52	21.28	34
35	27.58	21.55	27.49	21.67	27.39	21.79	27.30	21.91	35
36	28.37	22.16	28.27	22.29	28.17	22.41	28.08	22.53	36
37	29.16	22.78	29.06	22.91	28.96	23.03	28.86	23.16	37
38	29.94	23.40	29.84	23.53	29.74	23.66	29.64	23.79	38
39	30.73	24.01	30.63	24.14	30.52	24.28	30.42	24.41	39
40	31.52	24.63	31.41	24.76	31.30	24.90	31.20	25.04	40
41	32.31	25.24	32.20	25.38	32.09	25.52	31.98	25.66	41
42	33.10	25.86	32.98	26.00	32.87	26.15	32.76	26.29	42
43	33.88	26.47	33.77	26.62	33.65	26.77	33.53	26.91	43
44	34.67	27.09	34.55	27.24	34.42	27.39	34.31	27.54	44
45	35 46	27.70	35.34	27.86	35.22	28.01	35.09	28.17	45
46	36.25	28.32	36.12	28.48	36.00	28.64	35.87	28.79	46
47	37.04	28.94	36.91	29.10	36.78	29 26	36.65	29.42	47
48	37.82	29.55	37.70	29.72	37.57	29.88	37 43	30.04	48
49	38.61	30.17	38.48	30.34	38.35	30.50	38.21	30.67	49
50	39.40	30.78	39.27	30.95	39.13	31 13	38.99	31.39	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	52 Deg.		51¾ Deg.		51½ Deg.		51¼ Deg.		

Distance	38 Deg.		38¼ Deg.		38½ Deg.		38¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	40.19	31.40	40.05	31.57	39.91	31.75	39.77	31.92	51
52	40.98	32.01	40.84	32.19	40.70	32.37	40.55	32.55	52
53	41.76	32.63	41.62	32.81	41.48	32.99	41.33	33.17	53
54	42.55	33.25	42.41	33.43	42.26	33.62	42.11	33.80	54
55	43.34	33.86	43.19	34.05	43.04	34.24	42.89	34.43	55
56	44.13	34.48	43.98	34.67	43.83	34.86	43.67	35.05	56
57	44.92	35.09	44.76	35.29	44.61	35.48	44.45	35.68	57
58	45.70	35.71	45.55	35.91	45.39	36.11	45.23	36.30	58
59	46.49	36.32	46.33	36.53	46.17	36.73	46.01	36.93	59
60	47.28	36.94	47.12	37.15	46.96	37.35	46.79	37.56	60
61	48.07	37.56	47.90	37.76	47.74	37.97	47.57	38.18	61
62	48.86	38.17	48.69	38.38	48.52	38.60	48.35	38.81	62
63	49.64	38.79	49.47	39.00	49.30	39.22	49.13	39.43	63
64	50.43	39.40	50.26	39.62	50.09	39.84	49.91	40.06	64
65	51.22	40.02	51.05	40.24	50.87	40.46	50.69	40.68	65
66	52.01	40.63	51.83	40.86	51.65	41.09	51.47	41.31	66
67	52.80	41.25	52.62	41.48	52.43	41.71	52.25	41.94	67
68	53.58	41.86	53.40	42.10	53.22	42.33	53.03	42.56	68
69	54.37	42.48	54.19	42.72	54.00	42.95	53.81	43.19	69
70	55.16	43.10	54.97	43.34	54.78	43.58	54.59	43.81	70
71	55.95	43.71	55.76	43.96	55.57	44.20	55.37	44.44	71
72	56.74	44.33	56.54	44.57	56.35	44.82	56.15	45.07	72
73	57.52	44.94	57.33	45.19	57.13	45.44	56.93	45.69	73
74	58.31	45.56	58.11	45.81	57.91	46.07	57.71	46.32	74
75	59.10	46.17	58.90	46.43	58.70	46.69	58.49	46.94	75
76	59.89	46.79	59.68	47.05	59.48	47.31	59.27	47.57	76
77	60.68	47.41	60.47	47.67	60.26	47.93	60.05	48.20	77
78	61.46	48.02	61.25	48.29	61.04	48.56	60.83	48.82	78
79	62.25	48.64	62.04	48.91	61.83	49.18	61.61	49.45	79
80	63.04	49.25	62.83	49.53	62.61	49.80	62.39	50.07	80
81	63.83	49.87	63.61	50.15	63.39	50.42	63.17	50.70	81
82	64.62	50.48	64.40	50.77	64.17	51.05	63.95	51.33	82
83	65.40	51.10	65.18	51.38	64.96	51.67	64.73	51.95	83
84	66.19	51.72	65.97	52.00	65.74	52.29	65.51	52.58	84
85	66.98	52.33	66.75	52.62	66.52	52.91	66.29	53.20	85
86	67.77	52.95	67.54	53.24	67.30	53.54	67.07	53.83	86
87	68.56	53.56	68.32	53.86	68.09	54.16	67.85	54.46	87
88	69.34	54.18	69.11	54.48	68.87	54.78	68.63	55.08	88
89	70.13	54.79	69.89	55.10	69.65	55.40	69.41	55.71	89
90	70.92	55.41	70.68	55.72	70.43	56.03	70.19	56.33	90
91	71.71	56.03	71.46	56.34	71.22	56.65	70.97	56.96	91
92	72.50	56.64	72.25	56.96	72.00	57.27	71.75	57.58	92
93	73.28	57.26	73.03	57.58	72.78	57.89	72.53	58.21	93
94	74.07	57.87	73.82	58.19	73.57	58.52	73.31	58.84	94
95	74.86	58.49	74.61	58.81	74.35	59.14	74.09	59.46	95
96	75.65	59.10	75.39	59.43	75.13	59.76	74.87	60.09	96
97	76.44	59.72	76.18	60.05	75.91	60.38	75.65	60.71	97
98	77.22	60.33	76.96	60.67	76.70	61.01	76.43	61.34	98
99	78.01	60.95	77.75	61.29	77.48	61.63	77.21	61.97	99
100	78.80	61.57	78.53	61.91	78.26	62.25	77.99	62.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	52 Deg.		51¾ Deg.		51½ Deg.		51¼ Deg		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.78	0.63	0.77	0.63	0.77	0.64	0.77	0 64	1
2	1.55	1.26	1.55	1.27	1.54	1.27	1.54	1.28	2
3	2.33	1.89	2.32	1.90	2.31	1.91	2.31	1.92	3
4	3.11	2.52	3.10	2.53	3.09	2.54	3.08	2.56	4
5	3.89	3.15	3.87	3.16	3.86	3.18	3.84	3.20	5
6	4.66	3.78	4.65	3.80	4.63	3.82	4.61	3.84	6
7	5.44	4.41	5.42	4.43	5.40	4.45	5.38	4.48	7
8	6.22	5.03	6.20	5.06	6.17	5.09	6.15	5.12	8
9	6.99	5.66	6.97	5.69	6.94	5.72	6.92	5.75	9
10	7.77	6.29	7.74	6.33	7.72	6.36	7.69	6.39	10
11	8.55	6.92	8.52	6.96	8.49	7.00	8.46	7.03	11
12	9.33	7.55	9.29	7.59	9.26	7.63	9.23	7.67	12
13	10.10	8.18	10.07	8.23	10.03	8.27	9.99	8.31	13
14	10.88	8.81	10.84	8.86	10.80	8.91	10.76	8.95	14
15	11.66	9.44	11.62	9.49	11.57	9.54	11.53	9.59	15
16	12.43	10.07	12.39	10.12	12.35	10.18	12.30	10.23	16
17	13.21	10.70	13.16	10.76	13.12	10.81	13.07	10.87	17
18	13.99	11.33	13.94	11.39	13.89	11.45	13.84	11.51	18
19	14.77	11.96	14.71	12.02	14 66	12.09	14.61	12.15	19
20	15.54	12.59	15.49	12.65	15.43	12.72	15.38	12.79	20
21	16.32	13.22	16.26	13.29	16.20	13.36	16.15	13.43	21
22	17.10	13.84	17.04	13.92	16.98	13.99	16.91	14.07	22
23	17.87	14.47	17.81	14.55	17.75	14.63	17.68	14.71	23
24	18.65	15.10	18.59	15.18	18.52	15.27	18.45	15.35	24
25	19.43	15.73	19.36	15.82	19.29	15.90	19.22	15.99	25
26	20.21	16.36	29.13	16.45	20.06	16.54	19.99	16.63	26
27	20.98	16.99	20.91	17.08	20.83	17.17	20.76	17.26	27
28	21.76	17.62	21.68	17.72	21.61	17.81	21.53	17.90	28
29	22.54	18.25	22.46	18.35	22.38	18.45	22.30	18.54	29
30	23.31	18.88	23.23	18.98	23.15	19.08	23.07	19.18	30
31	24.09	19.51	24.01	19.61	23.92	19.72	23.83	19.82	31
32	24.87	20.14	24.78	20.25	24.69	20.35	24.60	20.46	32
33	25.65	20.77	25.55	20.88	25.46	20.99	25.37	21.10	33
34	26.42	21.40	26.33	21.51	26.24	21.63	26.14	21.74	34
35	27.20	22.03	27.10	22.14	27.01	22.26	26.91	22.38	35
36	27.98	22.66	27.88	22.78	27.78	22.90	27.68	23.02	36
37	28.75	23.28	28.65	23.41	28.55	23.53	28.45	23.66	37
38	29.53	23.91	29.43	24.04	29.32	24.17	29.22	24.30	38
39	30.31	24.54	30.20	24.68	30.09	24.81	29.98	24.94	39
40	31.09	25.17	30.98	25.31	30.86	25.44	30.75	25.58	40
41	31.86	25.80	31.75	25.94	31.64	26.08	31.52	26.22	41
42	32.64	26.43	32.52	26.57	32.41	26.72	32.29	26.86	42
43	33.42	27.06	33.30	27.21	33.18	27.35	33.06	27.50	43
44	34.19	27.69	34.07	27.84	33.95	27.99	33.83	28.14	44
45	34.97	28.32	34.85	28.47	34.72	28.62	34.60	28.77	45
46	35.75	28.95	35.62	29.10	35.49	29.26	35.37	29.41	46
47	36.53	29.58	36.40	29.74	36.27	29.90	36.14	30.05	47
48	37.30	30.21	37.17	30.37	37.04	30.53	36.90	30.69	48
49	38.08	30.84	37.95	31.00	37.81	31.17	37.67	31.33	49
50	38.86	31.47	38.72	31.64	38.58	31.80	38.44	31.97	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	39.63	32.10	39.49	32.27	39.35	32.44	39.21	32.61	51
52	40.41	32.72	40.27	32.90	40.12	33.08	39.98	33. 25	52
53	41.19	33.35	41.04	33.53	40.90	33.71	40.75	33 89	53
54	41.97	33.98	41.82	34.17	41.67	34.35	41.52	34.53	54
55	42.74	34 61	42.59	34.80	42.44	34.98	42.29	35.17	55
56	43.52	35.24	43.37	35.43	43.21	35.62	43.06	35.81	56
57	44.30	35.87	44.14	36.06	43.98	36.26	43.82	36.45	57
58	45.07	36.50	44.91	36.70	44.75	36.89	44.59	37.09	58
59	45.85	37.13	45.69	37.33	45.53	37.53	45.36	37.73	59
60	46.63	37.76	46.46	37.96	46.30	38.16	46.13	38.37	60
61	47 41	38.39	47.24	38.60	47.07	38.80	46.90	39.01	61
62	48.18	39.02	48.01	39.23	47.84	39.44	47.67	39.65	62
63	48.96	39.65	48.79	39.86	48.61	40.07	48.44	40.28	63
64	49.74	40.28	49.56	40.49	49.38	40.71	49.21	40.92	64
65	50.51	40.91	50.34	41.13	50.16	41.35	49.97	41.56	65
66	51.29	41.54	51.11	41.76	50.93	41.98	50.74	42.20	66
67	52.07	42.16	51.88	42.39	51.70	42.62	51.51	42.84	67
68	52.85	42.79	52.66	43.02	52.47	43.25	52.28	43.48	68
69	53.52	43.42	53.43	43.66	53.24	43.89	53.05	44.12	69
70	54.40	44.05	54.21	44.29	54.01	44.53	53.82	44.76	70
71	55.18	44.68	54.98	44.92	54.79	45.16	54.59	45.40	71
72	55.95	45.31	55.76	45.55	55.56	45.80	55.36	46.04	72
73	56.73	45.94	56.53	46.19	56.33	46.43	56.13	46.68	73
74	57.51	46.57	57.31	46.82	57.10	47.07	56.89	47.32	74
75	58.29	47.20	58.08	47.45	57.87	47.71	57.66	47.56	75
76	59.06	47.83	58.85	48.09	58.64	48.34	58.43	48.60	76
77	59.84	48.46	59.63	48.72	59.42	48.98	59.20	49.24	77
78	60.62	49.09	60.40	49.35	60.19	49.61	59.97	49.88	78
79	61.39	49.72	61.18	49.98	60.96	50.25	60.74	50.52	79
80	62.17	50.35	61.95	50.62	61.73	50.89	61.51	51.16	80
81	62.95	50.97	62.73	51.25	62.50	51.52	62.28	51.79	81
82	63.73	51.60	63.50	51.88	63.27	52.16	63.04	52.43	82
83	64.50	52.23	64.27	52.51	64.04	52.79	63.81	53.07	83
84	65.28	52.86	65.05	53.15	64.82	53.43	64.58	53.71	84
85	66.06	53.49	65.82	53.78	65.59	54.07	65.35	54.35	85
86	66.83	54.12	66.60	54.41	66.36	54.70	66.12	54.99	86
87	67.61	54.75	67.37	55.05	67.13	55.34	66.89	55.63	87
88	68.39	55.38	68.15	55.68	67.90	55.97	67.66	56.27	88
89	69.17	56.01	68.92	56.32	68.67	56.61	68.43	56.91	89
90	69.94	56.64	69.70	56.94	69.45	57.25	69.20	57.55	90
91	70.72	57.27	70.47	57.58	70.22	57.88	69.96	58.19	91
92	71.50	57.90	71.24	58.21	70.99	58.52	70.73	58.83	92
93	72.27	58.53	72.02	58.84	71.76	59.16	71.50	59.47	93
94	73.05	59.16	72.79	59.47	72.53	59.79	72.27	60.11	94
95	73.83	59.79	73.57	60.11	73.30	60.43	73.04	60.75	95
96	74.61	60.41	74.34	60.74	74.08	61.06	73.81	61.39	96
97	75.38	61.04	75.12	61.37	74.85	61.70	74.58	62.03	97
98	76.16	61.67	75.89	62.01	75.62	62.34	75.35	62.66	98
99	76.94	62.30	76.66	62.64	76.39	62.97	76.12	63.30	99
100	77.71	62.93	77.44	63.27	77.16	63.61	76.88	63.94	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	40 Deg.		40¼ Deg.		40½ Deg.		40¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.77	0.64	0.76	0.65	0.76	0.65	0.76	0.65	1
2	1.53	1.29	1.53	1.29	1.52	1.30	1.52	1.31	2
3	2.30	1.93	2.29	1.94	2.28	1.95	2.27	1.96	3
4	3.06	2.57	3.05	2.58	3.04	2.60	3.03	2.61	4
5	3.83	3.21	3.82	3.23	3.80	3.25	3.79	3.26	5
6	4.60	3.86	4.58	3.88	4.56	3.90	4.55	3.92	6
7	5.36	4.50	5.34	4.52	5.32	4.55	5.30	4.57	7
8	6.13	5.14	6.11	5.17	6.08	5.20	6.06	5.22	8
9	6.89	5.79	6.87	5.82	6.84	5.84	6.82	5.87	9
10	7.66	6.43	7.63	6.46	7.60	6.49	7.58	6.53	10
11	8.43	7.07	8.40	7.11	8.36	7.14	8.33	7.18	11
12	9.19	7.71	9.16	7.75	9.12	7.79	9.09	7.83	12
13	9.96	8.36	9.92	8.40	9.89	8.44	9.85	8.49	13
14	10.72	9.00	10.69	9.05	10.65	9.09	10.61	9.14	14
15	11.49	9.64	11.45	9.69	11.41	9.74	11.36	9.79	15
16	12.26	10.28	12.21	10.34	12.17	10.39	12.12	10.44	16
17	13.02	10.93	12.97	10.98	12.93	11.04	12.88	11.10	17
18	13.79	11.57	13.74	11.63	13.69	11.69	13.64	11.75	18
19	14.55	12.21	14.50	12.28	14.45	12.34	14.39	12.40	19
20	15.32	12.86	15.26	12.92	15.21	12.99	15.15	13.06	20
21	16.09	13.50	16.03	13.57	15.97	13.64	15.91	13.71	21
22	16.85	14.14	16.79	14.21	16.73	14.29	16.67	14.36	22
23	17.62	14.78	17.55	14.86	17.49	14.94	17.42	15.01	23
24	18.39	15.43	18.32	15.51	18.25	15.59	18.18	15.67	24
25	19.15	16.07	19.08	16.15	19.01	16.24	18.94	16.32	25
26	19.92	16.71	19.84	16.80	19.77	16.89	19.70	16.97	26
27	20.68	17.36	20.61	17.45	20.53	17.54	20.45	17.62	27
28	21.45	18.00	21.37	18.09	21.29	18.18	21.21	18.28	28
29	22.22	18.64	22.13	18.74	22.05	18.83	21.97	18.93	29
30	22.98	19.28	22.90	19.38	22.81	19.48	22.73	19.58	30
31	23.75	19.93	23.66	20.03	23.57	20.13	23.48	20.24	31
32	24.51	20.57	24.42	20.68	24.33	20.78	24.24	20.89	32
33	25.28	21.21	25.19	21.32	25.09	21.43	25.00	21.54	33
34	26.05	21.85	25.95	21.97	25.85	22.08	25.76	22.19	34
35	26.81	22.50	26.71	22.61	26.61	22.73	26.51	22.85	35
36	27.58	23.14	27.48	23.26	27.37	23.38	27.27	23.50	36
37	28.34	23.78	28.24	23.91	28.13	24.03	28.03	24.15	37
38	29.11	24.43	29.00	24.55	28.90	24.68	28.79	24.80	38
39	29.88	25.07	29.77	25.20	29.66	25.33	29.54	25.46	39
40	30.64	25.71	30.53	25.84	30.42	25.98	30.30	26.11	40
41	31.41	26.35	31.29	26.49	31.18	26.63	31.06	26.76	41
42	32.17	27.00	32.06	27.14	31.94	27.28	31.82	27.42	42
43	32.94	27.64	32.82	27.78	32.70	27.93	32.58	28.07	43
44	33.71	28.28	33.58	28.43	33.46	28.58	33.33	28.72	44
45	34.47	28.93	34.35	29.08	34.22	29.23	34.09	29.37	45
46	35.24	29.57	35.11	29.72	34.98	29.87	34.85	30.03	46
47	36.00	30.21	35.87	30.37	35.74	30.52	35.61	30.68	47
48	36.77	30.85	36.64	31.01	36.50	31.17	36.36	31.33	48
49	37.54	31.50	37.40	31.66	37.26	31.82	37.12	31.99	49
50	38.30	32.14	38.16	32.31	38.02	32.47	37.88	32.64	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance.
	50 Deg.		49¾ Deg.		49½ Deg.		49¼ Deg.		

Distance.	40 Deg.		40¼ Deg.		40½ Deg.		40¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	39.07	32.78	38.92	32.95	38.78	33.12	38.64	33.29	51
52	39.83	33.42	39.69	33.60	39.54	33.77	39.39	33.94	52
53	49.60	34.07	40.45	34.24	40.30	34.42	40.15	34.60	53
54	41.37	34.71	41.21	34.89	41.06	35.07	40.91	35.25	54
55	42.13	35.35	41.98	35.54	41.82	35.72	41.67	35.90	55
56	42.90	36.00	42.74	36.18	42.58	36.37	42.42	36.55	56
57	43.66	36.64	43.50	36.83	43.34	37.02	43.18	37.21	57
58	44.43	37.28	44.27	37.48	44.10	37.67	43.94	37.86	58
59	45.20	37.92	45.03	38.12	44.86	38.32	44.70	38.51	59
60	45.96	38.57	45.79	38.77	45.62	38.97	45.45	39.17	60
61	46.73	39.21	46.56	39.41	46.38	39.62	46.21	39.82	61
62	47.49	39.85	47.32	40.06	47.15	40.27	46.97	40.47	62
63	48.26	40.50	48.08	40.71	47.91	40.92	47.73	41.12	63
64	49.03	41.14	48.85	41.35	48.67	41.56	48.48	41.78	64
65	49.79	41.78	49.61	42.00	49.43	42.21	49.24	42.43	65
66	50.56	42.42	50.37	42.64	50.19	42.86	50.00	43.08	66
67	51.32	43.07	51.14	43.29	50.95	43.51	50.76	43.73	67
68	52.09	43.71	51.90	43.94	51.71	44.16	51.51	44.39	68
69	52.86	44.35	52.66	44.58	52.47	44.81	52.27	45.04	69
70	53.62	45.00	53.43	45.23	53.23	45.46	53.03	45.69	70
71	54.39	45.64	54.19	45.87	53.99	46.11	53.79	46.35	71
72	55.16	46.28	54.95	46.52	54.75	46.76	54.54	47.00	72
73	55.92	46.92	55.72	47.17	55.51	47.41	55.30	47.65	73
74	56.69	47.57	56.48	47.81	56.27	48.06	56.06	48.30	74
75	57.45	48.21	57.24	48.46	57.03	48.71	56.82	48.96	75
76	58.22	48.85	58.01	49.11	57.79	49.36	57.57	49.61	76
77	58.99	49.49	58.77	49.75	58.55	50.01	58.33	50.26	77
78	59.75	50.14	59.53	50.40	59.31	50.66	59.09	50.92	78
79	60.52	50.78	60.30	51.04	60.07	51.31	59.85	51.57	79
80	61.28	51.42	61.05	51.69	60.83	51.96	60.61	52.22	80
81	62.05	52.07	61.82	52.34	61.59	52.61	61.36	52.87	81
82	62.82	52.71	62.59	52.98	62.35	53.25	62.12	53.53	82
83	63.58	53.35	63.35	53.63	63.11	53.90	62.88	54.18	83
84	64.35	53.99	64.11	54.27	63.87	54.55	63.64	54.83	84
85	65.11	54.64	64.87	54.92	64.63	55.20	64.39	55.48	85
86	65.88	55.28	65.64	55.57	65.39	55.85	65.15	56.14	86
87	66.65	55.92	66.40	56.21	66.16	56.50	65.91	56.79	87
88	67.41	56.57	67.16	56.86	66.92	57.15	66.67	57.44	88
89	68.18	57.21	67.93	57.50	67.68	57.80	67.42	58.10	89
90	68.94	57.85	68.69	58.15	68.44	58.45	68.18	58.75	90
91	69.71	58.49	69.45	58.80	69.20	59.10	68.94	59.40	91
92	70.48	59.14	70.22	59.44	69.96	59.75	69.70	60.05	92
93	71.24	59.78	70.98	60.09	70.72	60.40	70.45	60.71	93
94	72.01	60.42	71.74	60.74	71.48	61.05	71.21	61.36	94
95	72.77	61.06	72.51	61.38	72.24	61.70	71.97	62.01	95
96	73.54	61.71	73.27	62.03	73.00	62.35	72.73	62.66	96
97	74.31	62.35	74.03	62.67	73.76	63.00	73.48	63.32	97
98	75.07	62.99	74.80	63.32	74.52	63.65	74.24	63.97	98
99	75.84	63.64	75.56	63.97	75.28	64.30	75.00	64.62	99
100	76.60	64.28	76.32	64.61	76.04	64.94	75.76	65.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	50 Deg.		49¾ Deg.		49½ Deg.		49¼ Deg.		

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.75	0.66	0.75	0.66	0.75	0.66	0.75	0.67	1
2	1.51	1.31	1.50	1.32	1.50	1.33	1.49	1.33	2
3	2.26	1.97	2.26	1.98	2.25	1.99	2.24	2.00	3
4	3.02	2.62	3.01	2.64	3.00	2.65	2.98	2.66	4
5	3.77	3.28	3.76	3.30	3.74	3.31	3.73	3.33	5
6	4.53	3.94	4.51	3.96	4.49	3.98	4.48	4.00	6
7	5.28	4.59	5.26	4.62	5.24	4.64	5.22	4.66	7
8	6.04	5.25	6.01	5.27	5.99	5.30	5.97	5.33	8
9	6.79	5.90	6.77	5.93	6.74	5.96	6.71	5.99	9
10	7.55	6.56	7.52	6.59	7.49	6.63	7.46	6.66	10
11	8.30	7.22	8.27	7.25	8.24	7.29	8.21	7.32	11
12	9.06	7.87	9.02	7.91	8.99	7.95	8.95	7.99	12
13	9.81	8.53	9.77	8.57	9.74	8.61	9.70	8.66	13
14	10.57	9.18	10.53	9.23	10.49	9.28	10.44	9.32	14
15	11.32	9.84	11.28	9.89	11.23	9.94	11.19	9.99	15
16	12.08	10.50	12.03	10.55	11.98	10.60	11.94	10.65	16
17	12.83	11.15	12.78	11.21	12.73	11.26	12.68	11.32	17
18	13.58	11.81	13.53	11.87	13.48	11.93	13.43	11.99	18
19	14.34	12.47	14.28	12.53	14.23	12.59	14.18	12.65	19
20	15.09	13.12	15.04	13.19	14.98	13.25	14.92	13.32	20
21	15.85	13.78	15.79	13.85	15.73	13.91	15.67	13.98	21
22	16.60	14.43	16.54	14.51	16.48	14.58	16.41	14.65	22
23	17.36	15.09	17.29	15.16	17.23	15.24	17.16	15.32	23
24	18.11	15.75	18.04	15.82	17.97	15.90	17.91	15.98	24
25	18.87	16.40	18.80	16.48	18.72	16.57	18.65	16.65	25
26	19.62	17.06	19.55	17.14	19.47	17.23	19.40	17.31	26
27	20.38	17.71	20.30	17.80	20.22	17.89	20.14	17.98	27
28	21.13	18.37	21.05	18.46	20.97	18.55	20.89	18.64	28
29	21.89	19.03	21.80	19.12	21.72	19.22	21.64	19.31	29
30	22.64	19.68	22.56	19.78	22.47	19.88	22.38	19.98	30
31	23.40	20.34	23.31	20.44	23.22	20.54	23.13	20.64	31
32	24.15	20.99	24.06	21.10	23.97	21.20	23.87	21.31	32
33	24.91	21.65	24.81	21.76	24.72	21.87	24.62	21.97	33
34	25.66	22.31	25.56	22.42	25.46	22.53	25.37	22.64	34
35	26.41	22.96	26.31	23.08	26.21	23.19	26.11	23.31	35
36	27.17	23.62	27.07	23.74	26.96	23.85	26.86	23.97	36
37	27.92	24.27	27.82	24.40	27.71	24.52	27.60	24.64	37
38	28.68	24.93	28.57	25.06	28.46	25.18	28.35	25.30	38
39	29.43	25.59	29.32	25.71	29.21	25.84	29.10	25.97	39
40	30.19	26.24	30.07	26.37	29.96	26.50	29.84	26.64	40
41	30.94	26.90	30.83	27.03	30.71	27.17	30.59	27.30	41
42	31.70	27.55	31.58	27.69	31.46	27.83	31.33	27.97	42
43	32.45	28.21	32.33	28.35	32.21	28.49	32.08	28.63	43
44	33.21	28.87	33.08	29.01	32.95	29.16	32.83	29.30	44
45	33.96	29.52	33.83	29.67	33.70	29.82	33.57	29.97	45
46	34.72	30.18	34.58	30.33	34.45	30.48	34.32	30.63	46
47	35.47	30.83	35.34	30.99	35.20	31.14	35.06	31.30	47
48	36.23	31.49	36.09	31.65	35.95	31.81	35.81	31.96	48
49	36.98	32.15	36.84	32.31	36.70	32.47	36.56	32.63	49
50	37.74	32.80	37.59	32.97	37.45	33.13	37.30	33.29	50
Distance.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	38.49	33.46	38.34	33.63	38.20	33.79	38.05	33.96	51
52	39.24	34.12	39.10	34.29	38.95	34.46	38.79	34.63	52
53	40.00	34.77	39.85	34.95	39.69	35.12	39.54	35.29	53
54	40.75	35.43	40.60	35.60	40.44	35.78	40.29	35.96	54
55	41.51	36.08	41.35	36.26	41.19	36.44	41.03	36.62	55
56	42.26	36.74	42.10	36.92	41.94	37.11	41.78	37.29	56
57	43.02	37.40	42.85	37.58	42.69	37.77	42.53	37.96	57
58	43.77	38.05	43.61	38.24	43.44	38.43	43.27	38.62	58
59	44.53	38.71	44.36	38.90	44.19	39.09	44.02	39.29	59
60	45.28	39.36	45.11	39.56	44.94	39.76	44.76	39.95	60
61	46.04	40.02	45.86	40.22	45.69	40.42	45.51	40.62	61
62	46.79	40.68	46.61	40.88	46.44	41.08	46.26	41.28	62
63	47.55	41.33	47.37	41.54	47.18	41.75	47.00	41.95	63
64	48.30	41.99	48.12	42.20	47.93	42.41	47.75	42.62	64
65	49.06	42.64	48.87	42.86	48.68	43.07	48.49	43.28	65
66	49.81	43.30	49.62	43.52	49.43	43.73	49.24	43.95	66
67	50.57	43.96	50.37	44.18	50.18	44.40	49.99	44.61	67
68	51.32	44.61	51.13	44.84	50.93	45.06	50.73	45.28	68
69	52.07	45.27	51.88	45.49	51.68	45.72	51.48	45.95	69
70	52.83	45.92	52.63	46.15	52.43	46.38	52.22	46.61	70
71	53.58	46.58	53.38	46.81	53.18	47.05	52.97	47.28	71
72	54.34	47.24	54.13	47.47	53.92	47.71	53.72	47.94	72
73	55.09	47.89	54.88	48.13	54.67	48.37	54.46	48.61	73
74	55.85	48.55	55.64	48.79	55.42	49.03	55.21	49.28	74
75	56.60	49.20	56.39	49.45	56.17	49.70	55.95	49.94	75
76	57.36	49.86	57.14	50.11	56.92	50.36	56.70	50.61	76
77	58.11	50.52	57.89	50.77	57.67	51.02	57.45	51.27	77
78	58.87	51.17	58.64	51.43	58.42	51.68	58.19	51.94	78
79	59.62	51.83	59.40	52.09	59.17	52.35	58.94	52.60	79
80	60.38	52.48	60.15	52.75	59.92	53.01	59.68	53.27	80
81	61.13	53.14	60.90	53.41	60.67	53.67	60.43	53.94	81
82	61.89	53.80	61.65	54.07	61.41	54.33	61.18	54.60	82
83	62.64	54.45	62.40	54.73	62.16	55.00	61.92	55.27	83
84	63.40	55.11	63.15	55.38	62.91	55.66	62.67	55.93	84
85	64.15	55.76	63.91	56.04	63.66	56.32	63.41	56.60	85
86	64.90	56.42	64.66	56.70	64.41	56.99	64.16	57.27	86
87	65.66	57.08	65.41	57.36	65.16	57.65	64.91	57.93	87
88	66.41	57.73	66.16	58.02	65.91	58.31	65.65	58.60	88
89	67.17	58.39	66.91	58.68	66.66	58.97	66.40	59.26	89
90	67.92	59.05	67.67	59.34	67.41	59.64	67.15	59.93	90
91	68.68	59.70	68.42	60.00	68.15	60.30	67.89	60.60	91
92	69.43	60.36	69.17	60.66	68.90	60.96	68.64	61.26	92
93	70.19	61.01	69.92	61.32	69.65	61.62	69.38	61.93	93
94	70.94	61.67	70.67	61.98	70.40	62.29	70.13	62.59	94
95	71.70	62.33	71.43	62.64	71.15	62.95	70.88	63.26	95
96	72.45	62.98	72.18	63.30	71.90	63.61	71.62	63.92	96
97	73.21	63.64	72.93	63.96	72.65	64.27	72.37	64.59	97
98	73.96	64.29	73.68	64.62	73.40	64.94	73.11	65.26	98
99	74.72	64.95	74.43	65.28	74.15	65.60	73.86	65.92	99
100	75.47	65.61	75.18	65.93	74.90	66.26	74.61	66.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.74	0.67	0.74	0.67	0.74	0.68	0.73	0.68	1
2	1.49	1.34	1.48	1.34	1.47	1.35	1.47	1.36	2
3	2.23	2.01	2.22	2.02	2.21	2.03	2.20	2.04	3
4	2.97	2.68	2.96	2.69	2.95	2.70	2.94	2.72	4
5	3.72	3.35	3.70	3.36	3.69	3.38	3.67	3.39	5
6	4.46	4.01	4.44	4.03	4.42	4.05	4.41	4.07	6
7	5.20	4.68	5.18	4.71	5.16	4.73	5.14	4.75	7
8	5.95	5.35	5.92	5.38	5.90	5.40	5.87	5.43	8
9	6.69	6.02	6.66	6.05	6.64	6.08	6.61	6.11	9
10	7.43	6.69	7.40	6.72	7.37	6.76	7.34	6.79	10
11	8.17	7.36	8.14	7.40	8.11	7.43	8.08	7.47	11
12	8.92	8.03	8.88	8.07	8.85	8.11	8.81	8.15	12
13	9.66	8.70	9.62	8.74	9.58	8.78	9.55	8.82	13
14	10.40	9.37	10.36	9.41	10.32	9.46	10.28	9.50	14
15	11.15	10.04	11.10	10.09	11.06	10.13	11.01	10.18	15
16	11.89	10.71	11.84	10.76	11.80	10.81	11.75	10.86	16
17	12.63	11.38	12.58	11.43	12.53	11.48	12.48	11.54	17
18	13.38	12.04	13.32	12.10	13.27	12.16	13.22	12.22	18
19	14.12	12.71	14.06	12.77	14.01	12.84	13.95	12.90	19
20	14.86	13.38	14.80	13.45	14.75	13.51	14.69	13.58	20
21	15.61	14.05	15.54	14.12	15.48	14.19	15.42	14.25	21
22	16.35	14.72	16.28	14.79	16.22	14.86	16.16	14.93	22
23	17.09	15.39	17.02	15.46	16.96	15.54	16.89	15.61	23
24	17.84	16.06	17.77	16.14	17.69	16.21	17.62	16.29	24
25	18.58	16.73	18.51	16.81	18.43	16.89	18.36	16.97	25
26	19.32	17.40	19.25	17.48	19.17	17.57	19.09	17.65	26
27	20.06	18.07	19.99	18.15	19.91	18.24	19.83	18.33	27
28	20.81	18.74	20.73	18.83	20.64	18.92	20.56	19.01	28
29	21.55	19.40	21.47	19.50	21.38	19.59	21.30	19.69	29
30	22.29	20.07	22.21	20.17	22.12	20.27	22.03	20.36	30
31	23.04	20.74	22.95	20.84	22.86	20.94	22.76	21.04	31
32	23.78	21.41	23.69	21.52	23.59	21.62	23.50	21.72	32
33	24.52	22.08	24.43	22.19	24.33	22.29	24.23	22.40	33
34	25.27	22.75	25.17	22.86	25.07	22.97	24.97	23.08	34
35	26.01	23.42	25.91	23.53	25.80	23.65	25.70	23.76	35
36	26.75	24.09	26.65	24.21	26.54	24.32	26.44	24.44	36
37	27.50	24.76	27.39	24.88	27.28	25.00	27.17	25.12	37
38	28.24	25.43	28.13	25.55	28.02	25.67	27.90	25.79	38
39	28.98	26.10	28.87	26.22	28.75	26.35	28.64	26.47	39
40	29.73	26.77	29.61	26.89	29.49	27.02	29.37	27.15	40
41	30.47	27.43	30.35	27.57	30.23	27.70	30.11	27.83	41
42	31.21	28.10	31.09	28.24	30.97	28.37	30.84	28.51	42
43	31.96	28.77	31.83	28.91	31.70	29.05	31.58	29.19	43
44	32.70	29.44	32.57	29.58	32.44	29.73	32.31	29.87	44
45	33.44	30.11	33.31	30.26	33.18	30.40	33.04	30.55	45
46	34.18	30.78	34.05	30.93	33.91	31.08	33.78	31.22	46
47	34.93	31.45	34.79	31.60	34.65	31.75	34.51	31.90	47
48	35.67	32.12	35.53	32.27	35.39	32.43	35.25	32.58	48
49	36.41	32.79	36.27	32.95	36.13	33.10	35.98	33.26	49
50	37.16	33.46	37.01	33.62	36.86	33.78	36.72	33.94	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		Distance.

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.90	34.13	37.75	34.29	37.60	34.46	37.45	34.62	51
52	38.64	34.79	38.49	34.96	38.34	35.13	38.18	35.30	52
53	39.39	35.46	39.23	35.64	39.08	35.81	38.92	35.98	53
54	40.13	36.13	39.97	36.31	39.81	36.48	39.65	36.66	54
55	40,87	36.80	40.71	36.98	40 55	37.16	40.39	37.33	55
56	41.62	37.47	41.45	37.65	41.29	37.83	41.12	38.01	56
57	42.36	38.14	42.19	38.32	42.02	38.51	41.86	38.69	57
58	43.10	38.81	42.93	39.00	42.76	39.18	42.59	39.37	58
59	43.85	39.48	43.67	39.67	43.50	39.86	43.32	40.05	59
60	44.59	40.15	44.41	40.34	44.24	40.54	44.06	40.73	60
61	45.33	40.82	45.15	41.01	44.97	41.21	44.79	41.41	61
62	46.07	41.49	45.89	41.69	45.71	41.89	45.53	42.09	62
63	46.82	42.16	46.63	42.36	46.45	42.56	46.26	42.76	63
64	47.56	42.82	47.37	43.03	47.19	43.24	47.00	43.44	64
65	48.30	43.49	48.11	43.70	47.92	43.91	47.73	44.12	65
66	49.05	44.16	48.85	44.38	48.66	44.59	48.47	44.80	66
67	49.79	44.83	49.59	45.05	49.40	45.26	49.20	45.48	67
68	50.53	45.50	50.33	45.72	50.13	45.94	49.93	46.16	68
69	51.28	46.17	51.07	46.39	50.87	46.62	50.67	46.84	69
70	52.02	46.84	51.82	47.07	51.61	47.29	51.40	47.52	70
71	52.76	47.51	52.56	47.74	52.35	47.97	52.14	48.19	71
72	53.51	48.18	53.30	48.41	53.08	48.64	52.87	48.87	72
73	54.25	48.85	54.04	49.08	53.82	49.32	53.61	49.55	73
74	54.99	49.52	54.78	49.76	54.56	49.99	54.34	50.23	74
75	55.74	50.18	55.52	50.43	55.30	50.67	55.07	50.91	75
76	56.48	50.85	56.26	51.10	56.03	51.34	55.81	51.59	76
77	57.22	51.52	57.00	51.77	56.77	52.02	56.54	52.27	77
78	57.97	52.19	57.74	52.44	57.51	52.70	57.28	52.95	78
79	58.71	52.86	58.48	53.12	58.24	53.37	58.01	53.63	79
80	59.45	53.53	59.22	53.79	58.98	54.05	58.75	54.30	80
81	60.19	54.20	59.96	54.46	59.72	54.72	59.48	54.98	81
82	60.94	54.87	60.70	55.13	60.46	55.40	60.21	55.66	82
83	61.68	55.54	61.44	55.81	61.19	56.07	60.95	56.34	83
84	62.42	56.21	62.18	56.48	61.93	56.75	61.68	57.02	84
85	63.17	56.88	62.92	57.15	62.67	57.43	62.42	57.70	85
86	63.91	57.55	63.66	57.82	63.41	58.10	63.15	58.38	86
87	64.65	58.21	64.40	58.50	64.14	58.78	63.89	59.06	87
88	65.40	58.88	65.14	59.17	64.88	59.45	64.62	59.73	88
89	66.14	59.55	65.88	59.84	65.62	60.13	65.35	60.41	89
90	66.88	60.22	66.62	60.51	66.35	60.80	66.09	61.09	90
91	67.63	60.89	67.36	61.19	67.09	61.48	66.82	61.77	91
92	68.37	61.56	68.10	61.86	67.83	62.15	67.56	62.45	92
93	69.11	62.23	68.84	62.53	68.57	62.83	68.29	63.13	93
94	69.86	62.90	69.58	63.20	69.30	63.51	69.03	63.81	94
95	70.60	63.57	70.32	63.87	70.04	64.18	69.76	64.49	95
96	71.34	64.24	71.06	64.55	70.78	64.86	70.49	65.16	96
97	72.08	64.91	71.80	65.22	71.52	65.53	71.23	65.84	97
98	72.83	65.57	72.54	65.89	72.25	66.21	71.96	66 52	98
99	73.57	66.24	73.28	66.56	72.99	66.88	72.70	67.20	99
100	74.31	66.91	74.02	67.24	73.73	67.56	73.43	67.88	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		

Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.73	0.68	0.73	0.69	0.73	0.69	0.72	0.69	1
2	1.46	1.36	1.46	1.37	1.45	1.38	1.44	1.38	2
3	2.19	2.05	2.19	2.06	2.18	2.07	2.17	2.07	3
4	2.93	2.73	2.91	2.74	2.90	2.75	2.89	2.77	4
5	3.66	3.41	3.64	3.43	3.63	3.44	3.61	3.46	5
6	4.39	4.09	4.37	4.11	4.35	4.13	4.33	4.15	6
7	5.12	4.77	5.10	4.80	5.08	4.82	5.06	4.84	7
8	5.85	5.46	5.83	5.48	5.80	5.51	5.78	5.53	8
9	6.58	6.14	6.56	6.17	6.53	6.20	6.50	6.22	9
10	7.31	6.82	7.28	6.85	7.25	6.88	7.22	6.92	10
11	8.04	7.50	8.01	7.54	7.98	7.57	7.95	7.61	11
12	8.78	8.18	8.74	8.22	8.70	8.26	8.67	8.30	12
13	9.51	8.87	9.47	8.91	9.43	8.95	9.39	8.99	13
14	10.24	9.55	10.20	9.59	10.16	9.64	10.11	9.68	14
15	10.97	10.23	10.93	10.28	10.88	10.33	10.84	10.37	15
16	11.70	10.91	11.65	10.96	11.61	11.01	11.56	11.06	16
17	12.43	11.59	12.38	11.65	12.33	11.70	12.28	11.76	17
18	13.16	12.28	13.11	12.33	13.06	12.39	13.00	12.45	18
19	13.90	12.96	13.84	13.02	13.78	13.08	13.72	13.14	19
20	14.63	13.64	14.57	13.70	14.51	13.77	14.45	13.83	20
21	15.36	14.32	15.30	14.39	15.23	14.46	15.17	14.52	21
22	16.09	15.00	16.02	15.07	15.96	15.14	15.89	15.21	22
23	16.82	15.69	16.75	15.76	16.68	15.83	16.61	15.90	23
24	17.55	16.37	17.48	16.44	17.41	16.52	17.34	16.60	24
25	18.28	17.05	18.21	17.13	18.13	17.21	18.06	17.29	25
26	19.02	17.73	18.94	17.81	13.86	17.90	18.78	17.98	26
27	19.75	18.41	19.67	18.50	19.58	18.59	19.50	18.67	27
28	20.48	19.10	20.39	19.19	20.31	19.27	20.23	19.36	28
29	21.21	19.78	21.12	19.87	21.04	19.96	20.95	20.05	29
30	21.94	20.46	21.85	20.56	21.76	20.65	21.67	20.75	30
31	22.67	21.14	22.58	21.24	22.49	21.34	22.39	21.44	31
32	23.40	21.82	23.31	21.93	23.21	22.03	23.12	22.13	32
33	24.13	22.51	24.04	22.61	23.94	22.72	23.84	22.82	33
34	24.87	23.19	24.76	23.30	24.66	23.40	24.56	23.51	34
35	25.60	23.87	25.49	23.98	25.39	24.09	25.28	24.20	35
36	26.33	24.55	26.22	24.67	26.11	24.78	26.01	24.89	36
37	27.06	25.23	26.95	25.35	26.84	25.47	26.73	25.59	37
38	27.79	25.92	27.68	26.04	27.56	26.16	27.45	26.28	38
39	28.52	26.60	28.41	26.72	28.29	26.85	28.17	26.97	39
40	29.25	27.28	29.13	27.41	29.01	27.53	28.89	27.66	40
41	29.99	27.96	29.86	28.09	29.74	28.22	29.62	28.35	41
42	30.72	28.64	30.59	28.78	30.47	28.91	30.34	29.04	42
43	31.45	29.33	31.32	29.46	31.19	29.60	31.06	29.74	43
44	32.18	30.01	32.05	30.15	31.92	30.29	31.78	30.43	44
45	32.91	30.69	32.78	30.83	32.64	30.98	32.51	31.12	45
46	33.64	31.37	33.51	31.52	33.37	31.66	33.23	31.81	46
47	34.37	32.05	34.23	32.20	34.09	32.35	33.95	32.50	47
48	35.10	32.74	34.96	32.89	34.82	33.04	34.67	33.19	48
49	35.84	33.42	35.69	33.57	35.54	33.73	35.40	33.88	49
50	36.57	34.10	36.42	34.26	36.27	34.42	36.12	34.58	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg		

Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.30	34.78	37.15	34.94	36.99	35.11	36.84	35.27	51
52	38.03	35.46	37.88	35.63	37.72	35.79	37.56	35.96	52
53	38.76	36.15	38.60	36.31	38.44	36.48	38.29	36.65	53
54	39.49	36.83	39.33	37.00	39.17	37.17	39.01	37.34	54
55	40.22	37.51	40.06	37.69	39.90	37.86	39.73	38.03	55
56	40.96	38.19	40.79	38.37	40.62	38.55	40.45	38.72	56
57	41.69	38.87	41.52	39.06	41.35	39.24	41.17	39.42	57
58	42.42	39.56	42.25	39.74	42.07	39.92	41.90	40.11	58
59	43.15	40.24	42.97	40.43	42.80	40.61	42.62	40.80	59
60	43.88	40.92	43.70	41.11	43.52	41.30	43.34	41.49	60
61	44.61	41.60	44.43	41.80	44.25	41.99	44.06	42.18	61
62	45.34	42.28	45.16	42.48	44.97	42.68	44.79	42.87	62
63	46.08	42.97	45.89	43.17	45.70	43.37	45.51	43.57	63
64	46.81	43.65	46.62	43.85	46.42	44.05	46.23	44.26	64
65	47.54	44.33	47.34	44.54	47.15	44.74	46.95	44.95	65
66	48.27	45.01	48.07	45.22	47.87	45.43	47.68	45.64	66
67	49.00	45.69	48.80	45.91	48.60	46.12	48.40	46.33	67
68	49.73	46.38	49.53	46.59	49.33	46.81	49.12	47.02	68
69	50.46	47.06	50.26	47.28	50.05	47.50	49.84	47.71	69
70	51.19	47.74	50.99	47.96	50.78	48.18	50.57	48.41	70
71	51.93	48.42	51.71	48.65	51.50	48.87	51.29	49.10	71
72	52.66	49.10	52.44	49.33	52.23	49.56	52.01	49.79	72
73	53.39	49.79	53.17	50.02	52.95	50.25	52.73	50.48	73
74	54.12	50.47	53.90	50.70	53.68	50.94	53.45	51.17	74
75	54.85	51.15	54.63	51.39	54.40	51.63	54.18	51.86	75
76	55.58	51.83	55.36	52.07	55.13	52.31	54.90	52.55	76
77	56.31	52.51	56.08	52.76	55.85	53.00	55.62	53.25	77
78	57.05	53.20	56.81	53.44	56.58	53.69	56.34	53.94	78
79	57.78	53.88	57.54	54.13	57.30	54.38	57.07	54.63	79
80	58.51	54.56	58.27	54.81	58.03	55.07	57.79	55.32	80
81	59.24	55.24	59.00	55.50	58.76	55.76	58.51	56.01	81
82	59.97	55.92	59.73	56.18	59.48	56.45	59.23	56.70	82
83	60.70	56.61	60.45	56.87	60.21	57.13	59.96	57.40	83
84	61.43	57.29	61.18	57.56	60.93	57.82	60.68	58.09	84
85	62.17	57.97	61.91	58.24	61.66	58.51	61.40	58.78	85
86	62.90	58.65	62.64	58.93	62.38	59.20	62.12	59.47	86
87	63.63	59.33	63.37	59.61	63.11	59.89	62.85	60.16	87
88	64.36	60.02	64.10	60.30	63.83	60.58	63.57	60.85	88
89	65.09	60.70	64.82	60.98	64.56	61.26	64.29	61.54	89
90	65.82	61.38	65.55	61.67	65.28	61.95	65.01	62.24	90
91	66.55	62.06	66.28	62.35	66.01	62.64	65.74	62.93	91
92	67.28	62.74	67.01	63.04	66.73	63.33	66.46	63.62	92
93	68.02	63.43	67.74	63.72	67.46	64.02	67.18	64.31	93
94	68.75	64.11	68.47	64.41	68.19	64.71	67.90	65.00	94
95	69.48	64.79	69.20	65.09	68.91	65.39	68.62	65.69	95
96	70.21	65.47	69.92	65.78	69.64	66.08	69.35	66.39	96
97	70.94	66.15	70.65	66.46	70.36	66.77	70.07	67.08	97
98	71.67	66.84	71.37	67.15	71.09	67.46	70.79	67.77	98
99	72.40	67.52	72.11	67.83	71.81	68.15	71.51	68.46	99
100	73.14	68.20	72.84	68.52	72.54	68.84	72.24	69.15	100
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg.		Distance.

Distance.	44 Deg.		44¼ Deg.		44½ Deg.		44¾ Deg.		45 Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.72	0.69	0.72	0.70	0.71	0.70	0.71	0.71	0.71	0.71	1
2	1.44	1.39	1.43	1.40	1.43	1.40	1.42	1.41	1.41	1.41	2
3	2.16	2.08	2.15	2.09	2.14	2.10	2.13	2.11	2.12	2.12	3
4	2.88	2.78	2.87	2.79	2.85	2.80	2.84	2.82	2.83	2.83	4
5	3.60	3.47	3.58	3.49	3.57	3.50	3.55	3.52	3.54	3.54	5
6	4.32	4.17	4.30	4.19	4.28	4.21	4.26	4.22	4.24	4.24	6
7	5.04	4.86	5.01	4.88	4.99	4.91	4.97	4.93	4.95	4.95	7
8	5.75	5.56	5.73	5.58	5.71	5.61	5.68	5.63	5.66	5.66	8
9	6.47	6.25	6.45	6.28	6.42	6.31	6.39	6.34	6.36	6.36	9
10	7.19	6.95	7.16	6.98	7.13	7.01	7.10	7.04	7.07	7.07	10
11	7.91	7.64	7.88	7.68	7.85	7.71	7.81	7.74	7.78	7.78	11
12	8.63	8.34	8.60	8.37	8.56	8.41	8.52	8.45	8.49	8.49	12
13	9.35	9.03	9.31	9.07	9.27	9.11	9.23	9.15	9.19	9.19	13
14	10.07	9.73	10.03	9.77	9.99	9.81	9.94	9.86	9.90	9.90	14
15	10.79	10.42	10.74	10.47	10.70	10.51	10.65	10.56	10.61	10.61	15
16	11.51	11.11	11.46	11.16	11.41	11.21	11.36	11.26	11.31	11.31	16
17	12.23	11.81	12.18	11.86	12.13	11.92	12.07	11.97	12.02	12.02	17
18	12.95	12.50	12.89	12.56	12.84	12.62	12.78	12.67	12.73	12.73	18
19	13.67	13.20	13.61	13.26	13.55	13.32	13.49	13.38	13.43	13.43	19
20	14.39	13.89	14.33	13.96	14.26	14.02	14.20	14.08	14.11	14.14	20
21	15.11	14.59	15.04	14.65	14.98	14.72	14.91	14.78	14.85	14.85	21
22	15.83	15.28	15.76	15.35	15.69	15.42	15.62	15.49	15.56	15.56	22
23	16.54	15.98	16.47	16.05	16.40	16.12	16.33	16.19	16.26	16.26	23
24	17.26	16.67	17.19	16.75	17.12	16.82	17.04	16.90	16.97	16.97	24
25	17.98	17.37	17.91	17.44	17.83	17.52	17.75	17.60	17.68	17.68	25
26	18.70	18.06	18.62	18.14	18.54	18.22	18.46	18.30	18.38	18.38	26
27	19.42	18.76	19.34	18.84	19.26	18.92	19.17	19.01	19.09	19.09	27
28	20.14	19.45	20.06	19.54	19.97	19.63	19.89	19.71	19.80	19.80	28
29	20.86	20.15	20.77	20.24	20.68	20.33	20.60	20.42	20.51	20.51	29
30	21.58	20.84	21.49	20.93	21.40	21.03	21.31	21.12	21.21	21.21	30
31	22.30	21.53	22.21	21.63	22.11	21.73	22.02	21.82	21.92	21.92	31
32	23.02	22.23	22.92	22.33	22.82	22.43	22.73	22.53	22.63	22.63	32
33	23.74	22.92	23.64	23.03	23.54	23.13	23.44	23.23	23.33	23.33	33
34	24.46	23.62	24.35	23.72	24.25	23.83	24.15	23.94	24.04	24.04	34
35	25.18	24.31	25.07	24.42	24.96	24.53	24.86	24.64	24.75	24.75	35
36	25.90	25.01	25.79	25.12	25.68	25.23	25.57	25.34	25.46	25.46	36
37	26.62	25.70	26.50	25.82	26.39	25.93	26.28	26.05	26.16	26.16	37
38	27.33	26.40	27.22	26.52	27.10	26.63	26.99	26.75	26.87	26.87	38
39	28.05	27.09	27.94	27.21	27.82	27.34	27.70	27.46	27.58	27.58	39
40	28.77	27.79	28.65	27.91	28.53	28.04	28.41	28.16	28.28	28.28	40
41	29.49	28.48	29.37	28.61	29.24	28.74	29.12	28.86	28.99	28.99	41
42	30.21	29.18	30.08	29.31	29.96	29.44	29.83	29.57	29.70	29.70	42
43	30.93	29.87	30.80	30.00	30.67	30.14	30.54	30.27	30.41	30.41	43
44	31.65	30.56	31.52	30.70	31.38	30.84	31.25	30.98	31.11	31.11	44
45	32.37	31.26	32.23	31.40	32.10	31.54	31.96	31.68	31.82	31.82	45
46	33.09	31.95	32.95	32.10	32.81	32.24	32.67	32.38	32.53	32.53	46
47	33.81	32.65	33.67	32.80	33.52	32.94	33.38	33.09	33.23	33.23	47
48	34.53	33.34	34.38	33.49	34.24	33.64	34.09	33.79	33.94	33.94	48
49	35.25	34.04	35.10	34.19	34.95	34.34	34.30	34.50	34.65	34.65	49
50	35.97	34.73	35.82	34.89	35.66	35.05	35.51	35.20	35.36	35.36	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	46 Deg.		45¾ Deg.		45½ Deg.		45¼ Deg.		45 Deg.		

Distance.	44 Deg.		44¼ Deg.		44½ Deg.		44¾ Deg.		45 Deg.		Distance.
	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	36.69	35.43	36.53	35.59	36.38	35.75	36.22	35.90	36.06	36.06	51
52	37.41	36.12	37.25	36.29	37.09	36.45	36.93	36.61	36.77	36.77	52
53	38.12	36.82	37.96	36.98	37.80	37.15	37.64	37.31	37.48	37.48	53
54	38.84	37.51	38.68	37.68	38.52	37.85	38.37	38.02	38.18	38.18	54
55	39.56	38.21	39.40	38.38	39.23	38.55	39.06	38.72	38.89	38.89	55
56	40.28	38.90	40.11	39.08	39.94	39.25	39.77	39.42	39.60	39.60	56
57	41.00	39.60	40.83	39.77	40.66	39.95	40.48	40.13	40.31	40.31	57
58	41.72	40.29	41.55	40.47	41.37	40.65	41.19	40.83	41.01	41.01	58
59	42.44	40.98	42.26	41.17	42.08	41.35	41.90	41.54	41.72	41.72	59
60	43.16	41.68	42.98	41.87	42.79	42.05	42.61	42.24	42.43	42.43	60
61	43.88	42.37	43.69	42.57	43.51	42.76	43.32	42.94	43.13	43.13	61
62	44.60	43.07	44.41	43.26	44.22	43.46	44.03	43.65	43.84	43.84	62
63	45.32	43.76	45.13	43.96	44.93	44.16	44.74	44.35	44.55	44.55	63
64	46.04	44.46	45.84	44.66	45.65	44.86	45.45	45.06	45.25	45.25	64
65	46.76	45.15	46.56	45.36	46.36	45.56	46.16	45.76	45.96	45.96	65
66	47.48	45.85	47.28	46.05	47.07	46.26	46.87	46.46	46.67	46.67	66
67	48.20	46.54	47.99	46.75	47.79	46.96	47.58	47.17	47.38	47.38	67
68	48.92	47.24	48.71	47.45	48.50	47.66	48.29	47.87	48.08	48.08	68
69	49.63	47.93	49.42	48.15	49.21	48.36	49.00	48.58	48.79	48.79	69
70	50.35	48.63	50.14	48.85	49.93	49.06	49.71	49.28	49.50	49.50	70
71	51.07	49.32	50.86	49.54	50.64	49.76	50.42	49.98	50.20	50.20	71
72	51.79	50.02	51.57	50.24	51.35	50.47	51.13	50.69	50.91	50.91	72
73	52.51	50.71	52.29	50.94	52.07	51.17	51.84	51.39	51.62	51.62	73
74	53.23	51.40	53.01	51.64	52.78	51.87	52.55	52.10	52.33	52.33	74
75	53.95	52.10	53.72	52.33	53.49	52.57	53.26	52.80	53.03	53.03	75
76	54.67	52.79	54.44	53.03	54.21	53.27	53.97	53.51	53.74	53.74	76
77	55.39	53.49	55.16	53.73	54.92	53.97	54.68	54.21	54.45	54.45	77
78	56.11	54.18	55.87	54.43	55.63	54.67	55.39	54.91	55.15	55.15	78
79	56.83	54.88	56.59	55.13	56.35	55.37	56.10	55.62	55.86	55.86	79
80	57.55	55.57	57.30	55.82	57.06	56.07	56.81	56.32	56.57	56.57	80
81	58.27	56.27	58.02	56.52	57.77	56.77	57.52	57.03	57.28	57.28	81
82	58.99	56.96	58.74	57.22	58.49	57.47	58.24	57.73	57.98	57.98	82
83	59.71	57.66	59.45	57.92	59.20	58.18	58.95	58.43	58.69	58.69	83
84	60.42	58.35	60.17	58.61	59.91	58.88	59.66	59.14	59.40	59.40	84
85	61.14	59.05	60.89	59.31	60.63	59.58	60.37	59.84	60.10	60.10	85
86	61.86	59.74	61.60	60.01	61.34	60.28	61.08	60.55	60.81	60.81	86
87	62.58	60.44	62.32	60.71	62.05	60.98	61.79	61.25	61.52	61.52	87
88	63.30	61.13	63.03	61.41	62.77	61.68	62.50	61.95	62.23	62.23	88
89	64.02	61.82	63.75	62.10	63.48	62.38	63.21	62.66	62.93	62.93	89
90	64.74	62.52	64.47	62.80	64.19	63.08	63.92	63.36	63.64	63.64	90
91	65.46	63.21	65.18	63.50	64.91	63.78	64.63	64.07	64.35	64.35	91
92	66.18	63.91	65.90	64.20	65.62	64.48	65.34	64.77	65.05	65.05	92
93	66.90	64.60	66.62	64.89	66.33	65.18	66.05	65.47	65.76	65.76	93
94	67.62	65.30	67.33	65.59	67.05	65.89	66.76	66.18	66.47	66.47	94
95	68.34	65.99	68.05	66.29	67.76	66.59	67.47	66.88	67.18	67.18	95
96	69.06	66.69	68.76	66.99	68.47	67.29	68.18	67.59	67.88	67.88	96
97	69.78	67.38	69.48	67.69	69.19	67.99	68.89	68.29	68.59	68.59	97
98	70.50	68.08	70.20	68.38	69.90	68.69	69.60	68.99	69.30	69.30	98
99	71.21	68.77	70.91	69.08	70.61	69.39	70.31	69.70	70.00	70.00	99
100	71.93	69.47	71.63	69.78	71.33	70.09	71.02	70.40	70.71	70.71	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance.
	46 Deg.		45¾ Deg.		45½ Deg.		45¼ Deg.		45 Deg.		

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